DEPARTMENT OF MICROBIOLOGY

SKELETON OF SYLLABUS OF M. Sc. MICROBIOLOGY, ACCORDING TO CHOICE BASED CREDIT SYSTEM (CBCS) JUNE 2022

Semester 1:						
Type of Course	**Name of the course**	**Hours per week**	**Credits**	**Internal Marks**	**External marks**	**Total**
MBCC-101	Concepts in Microbiology	4	4	30	70	100
MBCC-102	Microbial Metabolism and Energetics	4	4	30	70	100
MBCC-103	Microbial Diversity and Evolution	4	4	30	70	100
MBCC-104	Immunology	4	4	30	70	100
MBPR-106)	Combined Practicals	12	6		200	200
MBID-105)	Cell Biology	4	4	30	70	100
		Total	26			700

Semester 2:						
Type of Course	**Name of the course**	**Hours per week**	**Credits**	**Internal Marks**	**External marks**	**Total**
MBCC-207	Bioprocess Technology	4	4	30	70	100
MBCC-208	Molecular Biology	4	4	30	70	100
MBCC-209	Bacterial Genetics	4	4	30	70	100
MBCC-210	Recombinant DNA Technology	4	4	30	70	100
MBPR-212	Combined Practicals	12	6		200	200
MBID-211	Analytical Techniques in Biology	4	4	30	70	100
		Total	26			700

Semester 3:						
Type of Course	**Name of the course**	**Hours per week**	**credits**	**Internal Marks**	**External marks**	**Total**
MBCC-313	Bioinformatics, Microbial Genomics and Proteomics	4	4	30	70	100
MBCC-314	Epidemiology and Medical Microbiology	4	4	30	70	100
MBEC-315	Food and Dairy Microbiology/ Agriculture Microbiology	4	4	30	70	100
MBEC-316	Advanced Molecular Techniques / Entrepreneurship and IPR	4	4	30	70	100
MBEC-317)	Virology and Mycology/ Microbial Technology	4	4	30	70	100
MBPR-318)	Combined Practicals	12	6		200	200
		Total	26			700

Semester 4:						
Type of Course	**Name of the course**	**Hours per week**	**credits**	**Internal Marks**	**External marks**	**Total**
MBCC419	Biostatistics And Research Methodology	4	4	30	70	100
MBCC-420	Dissertation / Industrial training	36	18	200	400	600
		Total	22			700
Total credits: 100						

STYLE OF QUESTION PAPER

Each question from one unit of the syllabus. Each question carries 14 marks.

Question No.	Sub-question	Question type	Marks
1 Unit 1	a	Short questions (No internal Options)	4
	b	Descriptive Questions (1 out of 2)	10
2 Unit 2	a	Short questions (No internal Options)	4
	b	Descriptive Questions (1 out of 2)	10
3 Unit 3	a	Short questions (No internal Options)	4
	b	Descriptive Questions (1 out of 2)	10
4 Unit 4	a	Short questions (No internal Options)	4
	b	Descriptive Questions (1 out of 2)	10
5 Unit 5	a	Short questions (No internal Options)	4
	b	Descriptive Questions (1 out of 2)	10

PRACTICALS EXAM PATTERN

Time: 7 hours on each day

EX-1,2,3	120 MARKS
EX-5 JOURNAL	20
EX-6 VIVA-VOICE	40
EX-7 SPOTTING	20
Total	200

SEMESTER - I

MBCC101	Concepts in Microbiology	4hrs/week	4 Credits

Unit-1: Understanding microorganisms at molecular level (10 hrs)

- Prokaryotic and Eukaryotic cell structures
- Pure culture techniques- isolation, cultivation, enumeration and preservation of microbes
- Staining techniques- simple and differential staining, special staining techniques
- Nutritional requirements and nutritional grouping of microorganisms; Different media (simple, complex and defined)
- Growth curve, Axenic culture, Diauxic cultures, Synchronous culture, Continuous culture and Batch culture
- Methods of growth estimation
- Stringent responss and death of a bacterial cell
- Effects of Physical and Chemical factors on microbial growth

Unit 2: Control of microbial growth in environment (10 h)

- Terms used and environmental considerations
- Characteristics of ideal antimicrobial agent
- Physical agents: Temperature (high and low), radiation and filters
- Chemical agents: Liquid and gaseous agents

Unit 3: Control of microorganisms in vivo (10 h)

- Antimicroibial agents for therapeurtic purposes
- Antibiotics and their mode of action
- Antifungal drugs, antiviral drugs and antiprotozon drugs
- Mechanisms of antibiotic resistance in bacteria

Unit 4: Life in extreme environment environments (10 h)

- Distinguishing features, phylogenetic groups ecology and physiology of extremophiles
- Mechanism of adaption to habitat of extremophiles
- Major archaeal groups
- Importance and application of extremophiles

Unit 5: Interesting microorganisms/infective particles (08 h)

- Macrobacteria
- Viroids
- Prions
- Tardigrade

Reference Books:

1. Prescott, L. M. H., Klein, J. P., Prescott, D. A. L. M., Harley, J. P., & Klein, D. A. (2004). *Microbiology*. McGraw-Hill.
2. Madigan, M.T., Bender, K.S., Buckley, D. H., Sattley, W.M, Stahl, D.A. (2018). Brock Biology of Microorganisms, 15th edition, Pearson. USA. **ISBN-13: 9780134261928**
3. Pelczar, M. J., Chan, E. C. S., Krieg, N. R. (2019). Microbiology. McGraw-Hill.
4. Tortora, G., Funke, B., Case, C., Weber, D., Bair, W. Microbiology: An Introduction. 13th edition, Addison-Wesley.

MBCC 102	Microbial Metabolism and Energetics	4hrs/wk	4 Credits

Unit 1: Introduction to Metabolism and Bioenergetics (10h)

- General Overview of Metabolism, Primary and Secondary metabolism and their significance
- Laws of Thermodynamics
- Bioenergetics: The concept of free energy, Determination of ΔG & Energy rich compounds
- Energy metabolism: Introduction to metabolism, Role of ATP in metabolism, Role of reducing power in metabolism, Role of precursor metabolites in metabolism

Unit 2: Catabolism of Carbohydrates (10h)

- General overview of various metabolic pathways, regulations and their significance
- Glycolysis and its regulation
- Pentose phosphate pathway
- Citric acid cycle and its regulation
- Glyoxylate cycle

Unit 3: Metabolism of amino acids, nucleic acids and lipids (10h)

- Catabolism of amino acids – deamination, transamination, decarboxylation; Stickland Reactions
- Urea cycle including its regulation
- Biosynthesis of amino acids
- Biologically active amines, recycling of purine and pyrimidine nucleotides by salvage pathways
- Oxidation of Fatty Acids, Beta-Oxidation of Fatty Acids

Unit 4: Biosynthesis of ATP and methods to study biosynthesis (09h)

- Different modes of ATP generation and comparative study of ATP (energy budget)
- Electron transport chain: Introduction, Components of ETC and energy yield
- Anaerobic Respiration
- Methods of studying biosynthesis: Strategy of studying biosynthesis: use of biochemical mutants, use of isotopic labeling
- Bacterial photosynthesis

Unit 5: Metabolomics (09h)

- Metabolites and metabolite profiling
- Metabolomics: application and its role in system biology
- Work flow in metabolic studies
- Techniques for detection and quantification of metabolites
- Pathway and metabolome database
- Software tools for metabolomic analysis

Reference Books:

1. Madigan, M.T., Bender, K.S., Buckley, D. H., Sattley, W.M, Stahl, D.A. (2018).Brock Biology of Microorganisms, 15th edition, Pearson. USA. **ISBN-13: 9780134261928**
2. White D, Drummond, J., Fuqua, C. () The physiology and biochemistry of prokaryotes, 4th edition, Oxford University Press. ISBN: 9780195393040
3. Conn, E.E., Stumpf, R.K., Bruening, G., Doi, R.H. (2006). Outlines of Biochemistry, 5th edition Wiley.
4. Nelson, D.L., Cox, M., Lehninger (2017) Principles of Biochemistry, 7th edition, W.H. Freeman and Sapling Learning.
5. Moat, A. G., Foster, J.W., Spector, M.P. (2009) Microbial Physiology, 4th edition, Wiley Liss.
6. Metabolomics – A powerful Tool in Systems Biology, Edited by J.Nielsen and M.C. Jewett, Springer Publishers
7. Metabolome Analyses: an Introduction by Dr. Silas G. Villas-Bôas, Dr. Ute Roessner, Dr. Michael A. E. Hansen, Dr. Jørn Smedsgaard, Dr. Jens Nielsen. John Wiley & Sons, Inc, Print ISBN:9780471743446

MBCC 103	Microbial Diversity and Evolution	4hrs/week	4 Credits

Unit 1: Microbial taxonomy and evolution (11h)

- Types of classification: Phenetic, Phylogenetic and Genotypic; Basis of each classification, advantages and limitation
- Taxonomic ranks and Phylogenetic trees
- Evolution of three domains of life and concept of microbial species
- Microbial evolution processes
- Bergey's Manual of systematic bacteriology

Unit 2: Methods for studying microbial diversity (11h)

- Great plate anomaly
- Biochemical methods: Plate counts, community physiological profiling, FAME
- Molecular methods: G+C content, nucleic acid re-association and hybridization, DNA microarrays, PCR based methods (ARDRA, DGGE/TGGE, T-RFLP. ARISA)

Unit 3: Evolution of life on earth (08h)

- Different theories of origin of life
- Conditions on early earth and Urey and Miller experiment
- Origin of coacervates and other life forms
- Endosymbiotic theory and origin of eukaryotic cells

Unit 4: Characters of some important group of bacteria- 1 (08h)

- Classification of archaea
- Creanarchaeota: Pyrodictium, Sulfolobus
- Euryarchaeota: Methanobacterium, Halobacterium
- Cyanobacteria: anabaena
- Green sulfur and non-sulfur bacteria
- Purple sulfur and non-sulfur bacteria

Unit 5: Characters of some important group of bacteria- 1 (10 h)

- Alpha proteobacteria: Wolbachia, Rickettsia, Rhizobium, Agrobacterium, Azospirillum. Acetobacter
- Beta proteobacteria: Thiobacillus, Neisseria, Nitrosomonas
- Gamma proteobacteria: Pseudomonas, Enterobacteriales (order)
- Delta proteobacteria: Bdellovibrio
- Epsilon proteobacteria: Helicobacter
- Fermicutes: Mycoplasma, Bacillus
- Actinobacteria: Streptomyces, Frankia, Mycobacterium and Nocardia

References Books:

1. Madigan, M.T., Bender, K.S., Buckley, D. H., Sattley, W.M, Stahl, D.A. (2018). Brock Biology of Microorganisms, 15th edition, Pearson. USA. **ISBN-13: 9780134261928**
2. Pelczar, M. J., Chan, E. C. S., Krieg, N. R. (2019). Microbiology. McGraw-Hill.
3. Tortora, G.,Funke, B., Case, C., Weber, D., Bair, W. Microbiology: An Introduction. 13th edition, Addison-Wesley.

MBCC104	Immunology	4hrs/week	4 Credits

Unit 1: Immune cell receptors (10 h)

- Overview and historical perspective of immune system.
- Innate and Adaptive Immune system.
- Cells of immune system: B lymphocyte, T-lymphocytes, macrophages, Dentritic cells, natural killer and lymphokine activated killer cells.
- Organs of the immune system- primary and secondary lymphoid organs; Lymphatic system; Mucosal and Cutaneous associated Lymphoid tissue (MALT&CALT).
- Molecules of innate and acquired immune response - complements, interferon, other molecules

Unit 2: Antigens and Antibodies (10 h)

- Antigens and Immunogenicity – Characteristics and factors influencing immunogenicity epitopes, heptanes, cross reactivity and adjuvants.
- Antibodies – structure, classification and functions,
- Monoclonal antibody production
- Organization and expression of antibody genes
- Antigen and antibody interactions – Agglutination, precipitation, ELISA, RIA
- Antigen processing and presentation

Unit 3: Generation of B and T cell response (09 h)

- B cell maturation, activation and differentiation
- Generation of antibody diversity
- T-cell maturation, activation and differentiation and T-cell receptor
- Cell-mediated immune responses, ADCC
- Cytokines-properties and therapeutic use

Unit 4: Transplantation Immunology (10 h)

- Basis of self - non-self-discrimination and graft rejection
- MHC- general organization of MHC molecules and genes
- MHC restriction; HLA typing methods
- Immune Tolerance - central and peripheral
- Hypersensitivity reactions

Unit 5: Immune system in health and diseases (09 h)

- Vaccines & Vaccination – DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, passive & active immunization
- Recent advancement in vaccination
- Immuno deficiency diseases - Primary Immuno deficiency (AIDS) and Secondary Immuno deficiency (SCID)
- Autoimmunity and autoimmune diseases - Organ Specific (Graves disease, Insulin dependent diabetes mellitus)
- Systemic Autoimmune Diseases (Rheumatoid Arthritis, Multiple sclerosis)

Reference Books:

1. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2014). *Cellular and molecular immunology*. Elsevier Health Sciences.
2. Delves, P. J., Martin, S. J., Burton, D. R., &Roitt, I. M. (2011). *Roitt's essential immunology* (Vol. 20). John Wiley & Sons.
3. Kindt, T. J., Goldsby, R. A., Osborne, B. A., &Kuby, J. (2007). *Kuby immunology*. Macmillan.
4. Murphy, K., & Weaver, C. (2016). *Janeway'simmunobiology*. Garland Science.
5. Peakman, M., &Vergani, D. (2009). *Basic and clinical immunology*. Elsevier Health Sciences.
6. Coico, R., & Sunshine, G. (2015). *Immunology: a short course*. John Wiley & Sons.

MBI-105	Cell Biology	4 hrs/week	4 Credits

Unit 1: Cell signaling (10 h)

- Molecular basis of signal transduction: Basics of signal molecules, receptors and transduction
- Signaling through G-Proteins: GPCR, mechanism, role of cAMP in bacterial toxins
- Enzyme linked cell surface receptors: Types of receptor, mechanism, MAP kinase pathway and JAK STAT pathway.
- Secondary messenger system: cAMP, cGMP, DAG, IP_3 and Ca^{++}
- Protein sorting, targeting and trafficking.

Unit 2: Cell cycle, its regulation and apoptosis (10 h)

- Molecular aspects of cell cycle: phases of cell cycle, mitosis and meiosis
- Regulation of cell cycle events & check points
- Role of protein kinase in cell cycle: CDK-cyclins, CDK activating kinases, CDK inhibitors, phosphorylation and dephosphorylation of MPF, anaphase promoting complex.
- Phenomena of Apoptosis: Basic introduction, morphological changes.
- Factors regulating apoptotic death: Genes involved in apoptosis, caspases, extrinsic and intrinsic pathway, techniques to recognize apoptosis.

Unit 3: Molecular biology of cancer (10 h)

- Basic introduction of tumor and cancer, characteristics of cancer cells
- Genetic basis of cancer: tumor suppressor genes (p53, retinoblastoma) and their functions
- Genetic basis of cancer: proto-oncogenes, conversion of proto-oncogenes to oncogenes, viral oncogenes.
- Early detection & molecular diagnosis of cancer: biochemical assay, pap smear, histopathology, ames test, commet assay, mammogram, DNA fragmentation assay and nanotechnology.
- Cancer treatment present & future: surgery, radiation, chemotherapy.

Unit 4: Endo-membrane system and cytoskeleton (09 h)

- Structure and function of microbodies, golgi body, lysosomes & endoplasmic reticulum
- Microtubules: Structural organization and dynamics, role of tubulin, cilia and flagella.
- Microfilaments: G and F actin, dynamics of actin assembly, functional role of actin filaments.
- Motor Proteins: dynein, kinesis and myosins; mechanism of muscle contraction
- Intermediate filaments.

Unit 5: Protein sorting and transportation in cell (09 h)

- Protein transport across nucleus

- Protein sorting to mitochondria
- Protein sorting to endoplasmic reticulum, golgi and peroxisomes
- Vesicular transport
- Secretory pathways
- Endocytic pathway

Reference books:

1. Cooper, G. M., & Hausman, R. E. (2013). *The cell*: *A Molecular Approach*. 6th Edition. Sunderland: Sinauer Associates Inc.
2. Karp, G. (2013). *Cell and Molecular Biology: Concepts and Experiments.* 4th Edition. John Wiley & Sons.
3. Albert, B., Johnson, A., Lewis, J., Raff, M. (2016). *Molecular biology of the cell*. 6th Edition. Garland Science.
4. Berk, A., Zipursky, S., & Lodish, H. (2013). *Molecular Cell Biology*. 5th Edition. New York: W.H. Freeman.
5. Watson, J. D., Baker, T. A., Bell, S. B., Gann, A., Levine, M., & Losick, R. (2014). *Molecular Biology of the Gene*. 7th Edition. New York: Pearson Education
6. Jocelin E.K., Elliott S.C., Stephen T.K. (2018). *Lewin's Genes XII*. 12th Edition. Jones and Bartlett.

MBPR-106	Combined Practicals	12hrs/week	6 Credits

1. Diauxic growth curve
2. Determination of thermal death point (TDP) and thermal death time (TDT)
3. Determination of phenol coefficient
4. Determination of Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of given antibiotic on different organisms
5. Estimation of protein concentration by Folin Lowry method
6. Determination of acid number from fat sample
7. TLC separation of amino acids
8. Amplification of 16S rRNA gene by PCR
9. Diversity analysis by ARDRA
10. Purification of IgG
11. Single radial immunodiffusion
12. Ouchterlony test
13. Karyotyping

Reference Books:

1. Celis, J. E., Carter, N., Simons, K., Small, J. V., Hunter, T., & Shotton, D. (2005). *Cell biology, four-volume set: a Laboratory Handbook*. Academic Press
2. Celis, J. E. (1998). *Cell biology: A Laboratory Handbook*, Vol. 2. San Diego, CA: Academic Press.
3. Jayaraman, J. (2011). Laboratory Manual in Biochemistry. New Age International Private Limited.
4. Cappuccino, J. G., Sherman, N., & Microbiology, A. (2014). *A laboratory manual*. Pearson Education.
5. Benson, H. J. (2001). *Microbiological applications: a laboratory manual in general microbiology*. McGraw-Hill.

SEMESTER - II

MBCC 207	Bioprocess Technology	4hrs/week	4 Credits

Unit 1: Basic of Industrial Microbiology (09 h)

- Isolation and screening of Industrially useful Microorganisms
- Strain Improvement
- Preservation of Microorganisms
- Starter culture, its importance and preparation
- Substrates for Fermentation processes

Unit 2: Design of Fermentor and Growth rate parameter (09 h)

- Medium Optimization
- Sterilization of media and air
- Various Design and types of Fermentors & Bioreactor
- Batch, Fed-batch and Continuous culture operations
- Microbial growth and Death kinetics

Unit 3: Concepts of basic mode of fermentation processes (10 h)

- Aeration and agitation, Oxygen transfer rate
- Heat control, Mass transfer bioprocess
- Methods of scale up and their analysis
- Measurement and control of Bioprocess parameters
- Controller and application of Computer in Control system

Unit 4: Downstream Processing (10 h)

- Bioseparation- Filtration, Centrifugation, Sedimentation, Flocculation
- Cell disruption; Liquid-liquid extraction
- Purification by Chromatographic techniques; Reverse Osmosis and Ultra filtration
- Drying; Crystallization, Storage and Packaging
- Fermentation economics

Unit 5: Industrial production of chemicals (10 h)

- Alcohol fermentation, Vitamins (Vit. B12)
- Organic acids (Gluconic acid & Citric acid), Amino acids (Lysine & Glutamic acid)
- Antibiotics (Penicillin & streptomycin)
- Single cell protein
- Enzyme (Amylase, Protease & lipase)

Reference Books:

1. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2013). *Principles of fermentation technology*. Elsevier.
2. Crueger, W., & Crueger, A. (2006). *Biotechnology: a textbook of industrial microbiology*. Panima Publications.

3. MacNeil, B., & Harvey, L. M. (Eds.). (1990). *Fermentation: a practical approach*. IRL press.
4. Shuler, M. L., & Kargi, F. (2002). *Bioprocess engineering*. New York: Prentice Hall.
5. Bailey, J. E., & Ollis, D. F. (1986). *Biochemical. Engineering Fundamentals*. New York: McGraw-Hill.
6. Doran, P. M. (1995). *Bioprocess engineering principles*. Academic press.

MBCC 208	Molecular Biology	4hrs/week	4 Credits

Unit 1: Genes and Chromosomes (8 hrs)

- Fine structure of Gene, Split Genes, Overlapping Genes, Pseudogenes, Non- coding Genes and multi-gene families.
- Structure and organization of eukaryotic Chromosomes: Basic structure, Heterochromatin, Euchromatin, Histones, DNA, Nucleosome morphology and higher level organization (Super coiled loops, domains and scaffolds in eukaryotic chromosome), C-value Paradox
- Giant Chromosomes: Polytene and Lampbrush chromosomes
- Genomic organization of Prokaryotic & Eukaryotic cells

Unit 2: Classical and Population Genetics (8 hrs)

- Mendelian inheritance: Inheritance patterns & Laws of Heredity
- Gene Interaction: Allelic Interaction (Dominance, Incomplete Dominance & Co-Dominance), Non allelic Interaction (Supplementary, Complementary & Duplicative genes, Epistasis)
- Linkage & Linkage Maps
- Sex Determination and Extra Chromosomal Inheritance
- Genetic polymorphism, Genetic Drift & Hardy Weinberg Law of equilibrium

Unit 3: DNA: Structure and Replication (10 hrs)

- DNA as genetic material: Experimental evidences (Direct & Indirect Evidences), Watson & Crick Model, Alternative forms of DNA
- Enzymes & accessory proteins involved in DNA Replication
- Models of Replication in Prokaryotes
- Mechanism of Replication process in Prokaryotic & Eukaryotic DNA, Fidelity of Replication, Telomere synthesis-Role of Telomerase, Inhibitors of Replication

Unit 4: Transcription and Translation (14 hrs)

- Prokaryotic Transcription; Transcription unit, Promoters- Constitutive and Inducible, Regulatory elements, Bacterial RNA polymerases, Mechanism of transcription in Prokaryotes
- Eukaryotic Transcription; Eukaryotic Promoters and Enhancers, RNA Polymerase I, II, III structure and assembly, Transcription factors, Activators and repressors, Mechanism of transcription in Eukaryotes
- Post Transcriptional Modifications; 5'-Cap formation, 3'-end Polyadenylation, Splicing, RNA editing, Nuclear export of mRNA, RNA stability, Processing of tRNA and rRNA, Inhibitors of transcription. Ribozyme technology: mechanism of action and applications.
- Ribosomes, Genetic code, mechanism of activation of amino acids, Role of t RNA, Mechanism of translation in prokaryotes and eukaryotes, Co- and Post-translational modifications
- Inhibitors of Protein synthesis, Protein localization and Targeting, Protein stability, Protein turnover and degradation

Unit 5: Regulation of Gene expression in Prokaryotes & Eukaryotes (8 hrs)

- Operon concept- Inducible and repressible systems (Lac Operon, trp Operon, His Operon and Arabinose Operon) Attenuation & Termination
- Chromatin modification & Gene expression - Histone acetylation & Deacetylation

- Environmental regulation of Gene expression
- Gene silencing- DNA Methylation, RNAi pathway (si RNA and mi RNA)

Reference Books:

1. Watson, J. D., Baker, T. A., Bell, S. B., Gann, A., Levine, M., & Losick, R. (2008). *Molecular biology of the gene.* 6th edn. New York: Pearson Education.
2. Lewin, B. (2008). *genes IX*. Mc Graw-Hill Interamericana
3. Griffiths, A. J. F., Gilbert W. M., Lewontin, R.C.& Miller, J. H. (2002). *Modern Genetic Analysis, Integrating Genes and Genomes*. 2nd ed, W.H.Freeman
4. Brown, T. A. (2006). *Genomes*. Garland science
5. Weaver, W. (1970). *Molecular biology: Origin of the Term.* Science.
6. Winnacker, E. L. (1987). *From genes to clones: introduction to gene technology*. VCH Verlagsgesellschaft.
7. Brooker, R. J. (1999). *Genetics: Analysis and Principles*. Addison-Wesley.
8. Friefelder, D. (1985). *Essentials of Molecular Biology*. Jones and Bartlett.
9. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J. D., & Grimstone, A.V. (1995). *Molecular Biology of the Cell.* 3rd edn. Trends in Biochemical Sciences, 20(5), 210-210.

MBCC 209	Bacterial Genetics and Genomics	4hrs/week	4 Credits

Unit 1: Mutation **(08 h)**

- Mutation and its Types
- Mutation Rate and its Determination: Fluctuation test
- Mutagenesis
- Mutagens-Types, Physical Mutagens, DNA Reactive Chemicals, Base Analogs, Intercalating Agents, Metals and Biological Agents
- Ames test

Unit 2: Recombination **(09 h)**

- Types and models for homologous recombination
- Molecular mechanism of homologous recombination
- Molecular mechanism of site specific recombination
- Biological roles of homologous and site specific recombination
- Cre-Lox system and its role in molecular biology

Unit 3: DNA repair **(10 h)**

- Methyl directed mismatch repair
- Nucleotide excision repair
- Base excision repair
- Recombination repair
- SOS inducible repair
- Specific repair for oxidative DNA damage

Unit 4: Methods of gene transfer in bacteria **(11 h)**

- Transformation: history, mechanism and problem solving
- Conjugation: history, mechanism and problem solving
- Transduction: history, mechanism and problem solving

Unit 5: DNA sequencing techniques **(10 h)**

- Maxam and Gilbert method of DNA sequencing
- Sangar's di-deoxy or chain termination sequencing
- Next generation sequencing: Pyrosequencing, Nanopore sequencing
- Next generation sequencing: Ilumina sequencing and Sequencing by ligation
- Whole genome sequencing: Shotgun and single cell genome sequencing

References Books:

1. Watson, J. D., Baker, T. A., Bell, S. B., Gann, A., Levine, M., & Losick, R. (2008). *Molecular biology of the gene.* 6th edn. New York: Pearson Education.
2. Lewin, B. (2017). *Genes*. 12th Edition, Mc Graw-Hill Interamericana
3. Griffiths, A. J. F., Gilbert W. M., Lewontin, R.C.& Miller, J. H. (2002). *Modern Genetic Analysis, Integrating Genes and Genomes*. 2nded, W.H.Freeman
4. Brown, T. A. (2006). *Genomes*. Garland science
5. Willey, J.M., Sherwood, L.M., Woolverton, C. (2020) Prescott's Microbiology. 10th edition,
6. McGrawHill.

MBCC-210	Recombinant DNA Technology	4hrs/week	4 Credits

Unit-1: Enzymes involved in Genetic Engineering (10 hrs)

- Endo and Exo Nuclease: Classification, Mechanisms of enzyme action and role in Genetic engineering
- Restriction Endonuclease:Classification, Mechanisms of enzyme action and role in Genetic engineering
- Ligases –Classification, Mechanism of enzyme action and role in Genetic engineering
- Additional enzymes – DNA Polymerase, RNA Polymerase, Alkaline Phosphatases, Reverse transcriptase, Polynucleotide phosphorylase, polynucleotide kinases.

Unit-2: Gene cloning vectors and tools (10 hrs)

- Plasmid: Basic biology, Natural and Synthetic plasmid, Role of Plasmid in Genetic engineering.
- Phages: Basic biology and Role of Bacteriophage in Genetic engineering. Example of bacteriophage vector - Lambda phage vectors
- Artificial vectors : Cosmids, Phagemids, BAC, YAC, Shuttle vector
- Expression Vector – Vectors to facilitate protein purification, promote solubilization of expressed proteins
- Adaptors, Linkers, Homopolymer tailing

Unit-3: Cloning Strategies (10 hrs)

- Genomic libraries, PCR as an alternative to genomic DNA cloning
- c-DNA Synthesis & cloning, Full-length cDNA cloning
- Rapid amplification of cDNA ends (RACE)
- Probe preparation (Radiolabelled & non-radiolabelled)

Unit-4: Screening, Selection & Analysis of recombinants (8 hrs)

- Basic techniques for screening and selection of the clones:- use of chromatography substrate, Insertional inactivation, Complementation of defined mutation
- Sequence-dependent screening: Screening by hybridization, Screening by PCR
- Screening expression libraries : Immunological screening, South-Western and North-Western screening
- Functional cloning: Functional complementation, Screening by 'gain of function', Differential screening.
- Positional cloning, Chromosome walking and jumping

Unit-5: Advanced Techniques (10 hrs)

- PCR: Introduction, Types and Applications
- Sequencing of Nucleic acid : Enzymatic DNA sequencing, Chemical sequencing of DNA,Shotgun sequencing and Next-generation methods

- DNA markers:- RFLP, micro-minisatellites, SNP's, RAPD's, AFLP
- Application of Genetic engineering:
  Transgenic plants: BT cotton, roundup ready soybean

  Production of edible vaccines and biotech drugs

Suggested Reading:

1. S.B. Primrose, R.M. Twyman and R.W.Old.(2001) *Principles of Gene Manipulation. 6th Edition*, S. University Press.
2. J. Sambrook and D.W. Russel.(2001) *Molecular Cloning: A Laboratory Manual, Volume 1-3*, CSHL
3. Brown TA.(2006).*Gene Cloning, 3rd ed*. Garland Science

MBID 211	Analytical Techniques	4hrs/week	4 Credits

Unit 1: Microscopy and Radio isotopic techniques (9 hrs)

- Light Microscopy: - Bright field, Dark field, Fluorescent Microscopy, Phase contrast Microscopy, Polarizing Microscopy, Atomic Force Microscopy
- Electron Microscopy:-Transmission, EM & Scanning EM
- Radioactivity: Radioactive &Stable isotopes; Pattern and rate of radioactive decay; Units of radioactivity.
- Detection and Measurement of radioactivity; Interaction of Radiation with biological cells; Somatic and Genetic effects of radiations.
- Brief idea of radiation dosimetry; Cerenkov radiation; Measurement of stable isotopes; Falling drop method; Applications of isotopes in biological study

Unit 2: Spectroscopy (10 hrs)

- Electromagnetic Radiation: Basic Principles, Interaction of Electromagnetic Radiation with matter, Physical Phenomena of interaction
- UV-Visible spectroscopy, Atomic Absorption Spectroscopy &Atomic Emission Spectroscopy, Infrared (IR) Spectroscopy and Raman Spectroscopy,
- Mass spectrometry (MALDI-TOF)
- Magnetic Resonance (NMR), Electron Spin Resonance (ESR).
- X-ray Diffraction (XRD) and Crystallography, CD, ORD Spectroscopy

Unit 3: Centrifugation & Electrophoresis (9 hrs)

- Centrifugation: Basic principles; Settling time and velocity, Types of rotor, Sedimentation coefficient, RCF; Types of centrifuges
- Preparative centrifugation & Analytical centrifugation
- Electrophoresis: Basic Principles of electrophoresis; Support Media; Modes of electrophoresis
- Electrophoretic methods for Nucleic Acid Analysis: Agarose gel electrophoresis, Pulsed field gel electrophoresis, Polyacrylamide gel electrophoresis (PAGE), Denaturing PAGE
- Electrophoretic methods for Protein Analysis: SDS-PAGE, Gradient gel, Isoelectric focusing (2D Electrophoresis),High/Low voltage electrophoresis, Capillary electrophoresis; Disc gel electrophoresis

Unit 4: Chromatography techniques (10 hrs)

- Chromatography: Theory and principles.
- Definition of key terms: Retention time, Peak shape, Band broadenings, Column efficiency, Theoretical plate model (HETP), Rate Theory, Resolution, Selectivity.
- Partition theory: Retention &differential migration mechanism, Equilibrium between two phases, Properties of solvents (MP), Stationary phase and Supporting phase.
- Planar &Column Chromatography: TLC, HPTLC, Paper chromatography, Normal and

Reverse-phase, Gel permeation, Ion exchange, Adsorption, Partition and Affinity chromatography.

- Analytical Chromatography: Quantitative Biochemical Measurements, GC/ GLC, HPLC, UHPLC and FPLC, GC-MS, LC-MS Criteria of protein purity.

Unit 5: Advanced Biophysics (10 hrs)

- Biosensors: Introduction, Principle, Characteristics of Ideal Biosensor, Application of Biosensors, Types of Biosensors.
- Electrophysical techniques in diagnostics: Single neuron recording, patch-clamp recording, electrocardiogram, Brain activity recording, lesion and stimulation of brain, PET, MRI, fMRI, CAT, Density.
- CT Scanners and Their Applications, Overview of Digital Subtraction Radiography and Mammography
- Role and applications of biophysics in nuclear medicines, Principle of localization & usages of radiopharmaceuticals
- Flow cytometry

Reference Books:

1. Sambrook, J., Fritsch, E. F., &Maniatis, T. (1989). *Molecular cloning* (Vol. 2, pp. 14-9). New York: Cold spring harbor laboratory press.
2. Blau, K., & King, G. S. (Eds.). (1993). *Handbook of derivatives for chromatography* (Vol. 2). New York: Wiley.
3. Kindt, T. J., Goldsby, R. A., Osborne, B. A., &Kuby, J. (2007). *Kuby immunology*. Macmillan.
4. Hayat, M. A. (1974). *Principles and techniques of scanning electron microscopy. Biological applications. Volume 1*. Van Nostrand Reinhold Company.

MBPR-212	Combined Practicals	12hrs/week	6 Credits

1. Fermentation of Alcohol using Yeast and its estimation.
2. Bioassay of Antibiotic
3. Isolation of plasmid DNA from Bacteria by Alkaline lysis method
4. Qualitative and quantitative analysis of DNA using spectrophotometer
5. Gene Cloning
   PCR Amplification
   Restriction Digestion
   DNA Ligation
   Competent cell preparation
   Transformation
   Screening of recombinant (blue white screening or antibiotic resistance)
6. Conjugation
7. Transduction

Reference Books:

1. Sambrook, J., Fritsch, E. F., & Maniatis, T. (1989). Molecular cloning (Vol. 2, pp. 14-9). New York: Cold spring harbor laboratory press.
2. Cappuccino, James G., Sherman, Natalie S.1983. Microbiology: A Laboratory Manual. Pearson Publishing.11th Edition.
3. Verma, A.S., Das, S., Singh, A. (2014). Laboratory Manual in Biotechnology. S.Chand Publication.
4. Patel, R., Patel K. (2018). Experimental Microbiology. Aditya Publication.

SEMESTER - III

MBCC 313	Bioinformatics and Proteomics.	4hrs/week	4 Credits

Unit 1: Introduction and Bioinformatics Resources (10 h)

- Introduction to Bioinformatics: Definition, role, scope in different areas and current perspective.
- Database concepts, Biological Databases
- Nucleic acid sequence database: GenBank, ENA, DDBJ.
- Protein Resources: UniProtKB, SWISS-PROT, TrEMBL,
- Secondary sequence databases: PROSITE, Pfam, PRODOM.
- Structure database: PDB, NDB
- Small Molecule database: DrugBank,PubChem, ZINC

Unit: 2 Sequence alignments, analyses & primer designing (10 h)

- Basic concepts of sequence alignment,
- Needleman &Wunsch, Smith & Waterman algorithms for pair wise alignments,
- Multiple sequence alignment: Concept, Algorithm, tools and importance
- Biological sequences file formats: genbank, fasta, gcg, msf, nbrf-pir etc.
- Sequence similarity: similarity, identity and homology
- Scoring matrices: basic concept of a scoring matrix, PAM and BLOSUM series.
- Sequence-based Database Searches: BLAST and FASTA
- Primer designing

Unit 3: Phylogenetic Analysis (08 h)

- Phylogenetic analysis: Description and types of trees
- Computational Models in Phylogenetics: Various computational models of phylogenetic and molecular evolutionary analysis.
- Tree construction methods: distance based,
- Maximum Parsimony and Maximum Likelihood
- Tree Evaluation: Bootstrap and its computational aspects

Unit 4: Structural Bioinformatics and Drug designing (08 h)

- Structural Bioinformatics: Introduction, coordinate systems, Visualization & presentation of structure.
- Secondary structure: algorithms of Chou Fasman, GOR methods.
- Tertiary Structure: Homology modeling, threading method.
- Protein structure Alignment & structure assessment methods
- Introduction to drug discovery: History, analogue and structural drug discovery, ligand designing and optimization, Molecular docking – concept and methods.

Unit-5: Proteome analysis

- Two dimensional separation of total cellular proteins,
- Isolation and sequence analysis of individual protein spots by Mass Spectroscopy.
- Protein microarrary advantages and disadvantages of DNA and protein microarrays.

Reference Books:

1. Biostatistics: A Foundation for Analysis in Health Sciences, (6th edition), W W Daniel, John Wiley and Sons Inc., 1995.

2. Fundamentals of Biostatistics, Khan, Publishing Corporation, 1999
3. Lesk, A. (2013). *Introduction to bioinformatics*. Oxford University Press.
4. Mount, D. W., & Mount, D. W. (2001). *Bioinformatics: sequence and genome analysis* (Vol. 2). New York: Cold spring harbor laboratory press.
5. Rastogi, S. C., Mendriratta, N., & Rastogi, P. (2006). *Bioinformatics: Concepts, Skills & Applications*. CBS Publishers & Distributors Pvt. Limited.
6. Baxevanis Andreas, D., Davison Daniel, B., Page Roderic, D. M., Petsko Gregory, A., Stein Lincoln, D., & Stormo Gary, D. (2003). *Current protocols in bioinformatics*. John Wiley & Sons.
7. Higgens, D. G., Taylor, W. R., & Webster, D. M. (2000). *Protein Structure Prediction: Methods and Protocols.* Springer Science & Business Media.
8. Rastogi, S. C., Rastogi, P., & Mendiratta, N. (2008). *Bioinformatics Methods and Applications: Genomics Proteomics and Drug Discovery 3rd ed*. PHI Learning Pvt. Ltd.
9. Xiong, J. (2006). *Essential bioinformatics.* Cambridge University Press.
10. Baxevanis, A. D., & Ouellette, B. F. (2004). *Bioinformatics: a practical guide to the analysis of genes and proteins* (Vol. 43). John Wiley &Sons.
11. Eidhammer, I., Jonassen, I. T., William, R., & Inge Jonassen, W. R. T. (2004). *Protein Bioinformatics: An algorithmic approach to sequence and structure analysis* (Vol. 1). John Wiley& Sons.

MBCC- 314	Epidemiology and Medical Microbiology	4hrs/wk	4 Credits

Unit 1: Epidemiology **(9 hrs)**

- Epidemiology: definition and history
- Tools and terms used in epidemiology
- Emerging and reemerging diseases and Bioterrorism
- Infectious disease cycle
- Pathogenicity islands and virulence factors

Unit 2: Basics of clinical microbiology **(10 hrs)**

- Overview of clinical microbiology laboratroy
- Biosafety and its different levels
- Identification of microorganisms from clinical specimens
- Clinical immunology

Unit 4: Study of air borne infections **(9 hrs)**

- Tuberculosis
- Pneumonia
- Influenza
- SARS-CoV2
- Aspergillosis

Unit 5: Study of food, water and vector borne dieseases **(9 hrs)**

- Typhoid, Cholera and Samonellosis
- Gasteroenteritis caused by E. coli and Noro and Rota virus
- Hepatitis and Botulism
- Malaria and Dengu
- Staphylococcal infections

References:

1. Willey, J. M., Sherwood, L., and Woolverton, C. J. (2017). Prescott's Microbiology, 10th Ed., New York: McGraw-Hill Education.
2. Greenwood, D., Slack, R., and Barer, M. (2012). Medical Microbiology A Guide to Microbial Infections, 18th Ed., Churchill Livingstone, Elsevier.
3. Pelczar, Chan, and Krieg (1993). Microbiology – Concepts and Application Interna-tional Ed., McGraw-Hill Education.
4. Ananthnarayan, R and Paniker C. K. (2009). Textbook of Microbiology, 8th Ed., Uni-versities Press (India) Pvt. Limited.

MBEC 315	Food And Dairy Microbiology	4hrs/wk	4 Credits

Unit . 1: Food Microbiology (9 hrs)

- Introduction to Food Microbiology
- Factors affecting interactions of microorganisms with food: intrinsic and extrinsic factors
- Objectives, Importance and functions of quality control.
- Food quality standards and control system. Food industries and QA in production, ISO certifications
- Food standard and safety regulations: BIS, ISI, FSSAI, FDA, CODEX, HACCP

Unit . 2: Food Processing and Packaging Technology (9 hrs)

- Microbial flora associated with fresh foods.
- Scope, importance and principles of food processing.
- Application of enzymes in food processing
- Processing of fruits, vegetables, cereals, pulses, meat and fishes.
- Introduction to packaging, principles of development of protective packaging

Unit . 3: Food spoilage and Preservation (10 hrs)

- Microbial spoilage of food: fresh food and canned food.
- Physical and chemical factors influencing microbial spoilage of food.
- Types of microbes normally associated with spoilage and biochemical change.
- Preservation of foods: General principles & methods of food preservation
- Physical methods: Low temperature, high temperature, osmotic dehydration, blanching, canning, dielectric heating, microwave processing, membrane technology, irradiation.
- Chemical Methods: preservatives, salts, sugars, antioxidants and spices.
- Food additives and adulterants

Unit . 4: Dairy technology (10 hrs)

- Composition of Milk, types of microbes in milk
- Microbial analysis of milk: SPC, Direct count, MBRT, Resazurin test
- Types of spoilage of milk and milk products, Milk borne infections affecting human and milking animal.
- Processing of milk products: Cheese, yoghurt, dahi, shrikhand, paneer, skimmed milk
- Preservation of milk and its products

Unit . 5: Advancement in Food technology (10 hrs)

- Introduction to neutraceuticals and functional foods.
- GM Foods and issues concerning GM foods.
- Bioactive foods: prebiotics, probiotics and synbiotics.
- Interaction between food and genes.

Reference Books:

1. Frobisher, M. (1974). Fundamentals of Microbiology 9th edition. Philadephia. Sanders Company.

2. Pelczar, M.J., Chan, E.C.S. and N.R. Kreig (1993). Microbiology, 5th Edition. New Delhi: Tata Mc Graw Hill Publishing co. Ltd.
3. Presscott, M.J., Harley, J.P., Klein, D.A. (2002). Microbiology, 5th Edition. New York: WCB Mc GrawHill publication.
4. Frazier, W.C., Westhoff, D.C. (1978). Food Microbiology. Tata McGraw-Hill Publishing Company.
5. Swaminathan, M. (1990). Food Science, Chemistry and Experimental Foods. Mysore: Bappco Book Publishing Company.
6. Jay, J.J., Loessener, M.J., Golden, D.A. (2005). Modern Food Microbiology: Springer publication.
7. Prajapati, J.B. (1995). Fundamentals of Dairy Microbiology: Ekta Publication.

MBEC 315	Agricultural Microbiology	4hrs/wk	4 Credits

Unit 1: Microbes and Soil Fertility (10hrs)

- Physical and Chemical properties of soil
- Role of Microbes in soil fertility
- Soil fertility Evaluation and Improvement
- Interactions among soil microorganisms
- Organic Farmimg

Unit 2: Plant Microbe Interaction (09hrs)

- Rhizosphere Microorganisms : Phyllosphere, Spermosphere and Rhizoplane
- Methods of Enumeration, Rhizosphere Effect
- Factors affecting Rhizosphere Microorganisms
- Positive and Negative outcomes of plant microbe interaction
- PGPR, Siderophore, Mycorrhiza and VAM

Unit 3: Biological Nitrogen Fixation (10hrs)

- Nitrification, Dinitrification
- Symbiotic Nitrogen Fixation *(Rhizobium, Frankia)*
- Asymbiotic Nitrogen Fixation *(Azotobacter, Azospirillum)*
- Nitrogenase enzyme, *nif* genes and Molecular mechanism of Nitrogen fixation
- Role of nodulin genes in nodule development and symbiosis
- Genetic engineering of BNF

Unit 4: Biofertilizers and Biopestisides (10hrs)

- **Biofertilizers** – Types, Production and Quality control
- Cultivation and mass production of Bioinoculants – Azotobacter, Rhizobium, Azospirillum, Cyanobacteria, Azolla and Phospahte Solubilizing Microorgansms – Production and applications
- Carrier based inoculants
- **Biopesticides –** Types and applications (*Psedomonas Fluoroscence, Bacillus thuringiensis, Trichoderma harzianum, Trichoderma viridae, Nuclear Polyhedrosis Virus)*

Unit 5: Molecular Plant Pathology (09 hrs)

- Recognition and entry of pathogens into host cell, alteration of host behavior by pathogen
- Molecular mechanism of disease establishment; enzymes, phytotoxins, growth regulators, involvement of elicitors; role of R and r genes in disease development
- Molecular mechanism of disease diagnosis.
- Resistance Mechanism in Plants, Systemic Resistance, Resistance genes, Phytoalexins. PR Proteins, Signalling Mechanisms.

Reference Books:

- Atlas, R.M., Bertha, R. (1997). Microbial Ecology, 4th Edition: Benjamin Cummings publication
- Pelczar, M.J., Chan, E.C.S. and N.R. Kreig (1993). Microbiology, 5th Edition. New Delhi: Tata Mc Graw Hill Publishing co. Ltd.
- Alexander, M. (1977). Introduction to soil microbiology, 2nd edition. Wiley publication.
- Purohit, S.S. (2007). Microbiology-Fundamentals and Applications, 6th Edition. New Delhi: Agrobios Publications.
- Rangaswami, G., Mahadevan, A. (2004). Diseases of Crop plants in India: PHI publication.
- Presscott, M.J., Harley, J.P., Klein, D.A. (2002). Microbiology, 5th Edition. New York: WCB Mc GrawHill publication.

MBEC 316	Entrepreneurship and IPR	4hrs/week	4 Credits

Unit 1: Entrepreneurship

- Concept and its importance in present era
- Characteristics of an entrepreneur
- Starting a business: idea generation, opportunity recognition, feasibility study
- Starting a business: Business plan preparation and pitching it before investors

Unit 2: Planning a Business

- Marketing plan: marketing research, marketing plan, contingency plan
- Organizational plan: Form of ownership, organization structure, manpower planning
- Financial plan: cash budget, working capital, performa income statement and cash flow, break- even point analysis

Unit 3: IPR and Patent law

- Introduction to IPR, kinds of IPR, advantages and disadvantages
- International regime relating to IPR
- TRIPS and other Treaties (WIPO, WTO, GATTS)
- Patent Act 1970 and amendments 1999, 2000, 2002 and 2005

Unit 4: Patent laws and practices

- Patentable subject matter, patentability criteria, non-patentable inventions
- Patenting microorganisms and process patent
- Right of patentee, procedure for granting and obtaining patent
- Working of patents, compulsory license, acquisition, surrender, revocation, restoration and transfer of patent
- Infringement: its types, determination of infringement, controller and defences to infringement

Unit 5: Copyright, trademarks and GI

- Copyright: Introduction, copyright act 1957, grant, infringement and dfences, copyright societies
- Trademark: Introduction, need for protection, kinds, registration procedure, infringement and defences
- GI: Introduction, criteria for grant, advantages and examples
- Current issues of patents: discuss any one recent issue related to biological science

References:

1. Entrepreneurship: New venture creation by David Holt, Prentice Hall of India Pvt. Ltd
2. Entrepreneurship (Fifth Edition 2002); Robert Hisrich, Michael Peters; Tata McGraw Hill Publication
3. P. Narayanan (Eastern Law House), Intellectual Property Law

4. R.K. Nagarjan, Intellectual Property Law
5. Ganguli (Tata Megraw), Intellectual Property Rights
6. Beier, F.K., Crespi, R.S. and Straus, T. Biotechnology and Patent protection-Oxford and IBH Publishing Co. New Delhi.
7. Intellectual property rights and Bio-Technology (Biosafety and Bioethics), Anupam Singh, Ashwani Singh, NPH, New Delhi
8. Sasson A, Biotechnologies and Development, UNESCOPublications.
9. Singh K, Intellectual Property rights on Biotechnology, BCIL, New Delhi

MBEC 316	Advanced Molecular Techniques	4hrs/week	4 Credits

Unit 1: Techniques used in gene detection and gene expression studies (9 hrs)

- Blotting and hybridization studies: Southern hybridization, Northern hybridization, Western hybridization, Fluorescent in situ hybridization
- Subtractive hybridization, Differential display
- RT PCR, Real time PCR, RNA arbitrarily primer (RAP)-PCR
- SAGE, DNA microarray

Unit 2: DNA-protein interaction techniques (10 hrs)

- DNA-protein cross-linking assay, Gel mobility shift assay, Dnase I foot printing and Sl nuclease mapping, Chromatin immunoprecipitation (ChIP)
- Protein- protein interactions: Chemical cross-linking, Co-immunoprecipitation (CIP), Tandam affinity tags (TAT), Phage display, Fluorescent resonance energy transfer (FRET), Yeast-2-hybid, Yeast-3-hybid and their various version

Unit 3: Reporter and marker genes (10 hrs)

- Introduction to reporter and marker genes
- Application of reporter and markers in biotechnology
- Green Fluorescent Protein (GFP), Chloramphenicol acetyl transferase (cat), Neomycin phosphoryltransferase II (nptII), Luciferase, β- galactosidase, β – lactamase gene and β-glucuronidase

Unit 4: Gene Silencing and gene editing techniques (10 hrs)

- Transcriptional and post transcriptional gene silencing
- Mechanism of RNAi
- Application of gene silencing
- Importance and tools of gene editing technologies
- CRISPR-Cas9 and TALEN

Unit 5: Protein folding and protein engineering

- Introduction to protein folding and principals governing protein folding
- *In vitro* vs *In vivo* protein folding, role of molecular chaperons
- Relevance of protein folding to biotechnology and protein misfolding diseases
- Rational of protein engineering
- Methods and approaches: Directed evolution and gene shuffling, random mutagenesis and selection of engineered proteins, gene modification at specific sites, synthesis of complete gene. Engineering by gene fusion.

Reference Books:

1. Strauch, M. A. Protein–DNA Interactions: Techniques Used. *eLS*, John Wiley & Sons.

2. Brown, T. A., & Brown, T. (2016). *Gene cloning and DNA analysis: an introduction*. John Wiley & Sons.
3. Dale, J. W., Von Schantz, M., & Plant, N. (2012). *From genes to genomes: concepts and applications of DNA technology*. John Wiley & Sons.
4. Research and review papers

MBEC 317	Microbial Technology	4hrs/week	4 Credits

Unit 1: Biofuel cells

- Definition and history and types: Mediated and Mediator free
- Variants of mediator less biofuel cells
- Soil based, Phototrophic biofilm, Nanoporous and ceramic membrane based fuel cells
- Mechanism of working
- Applications

Unit 2: Microbial cell factories

- Definition and history
- Genome editing tools to improve MCFs: ZFNs
- Genome editing tools to improve MCFs: CRISPRs
- Genome editing tools to improve MCFs: TALENS
- Applications of MCFs

Unit 3: Agriculture and food technological microbiology

- Microbial technologies for biocontrol and insect resistant plant
- Microbial technologies for plant growth promotion
- Probiotics and their importance
- Genetic engineered microbes in food industry

Unit 4: Medical and environment technological microbiology

- Controlling vectors using bacteria: Wolbachia
- Microbes in/as vaccines
- Biosurfactants
- Bioplastics from microbes

Unit 5: Waste water treatment and Bioleaching

- Biological oxygen demand: concept and significance
- Eutrophication and algal bloom
- Waste water treatment: primary, secondary and tertiary treatment

- Bioleaching of metals and bio-recovery oil (MEOR)

References:

1. Review papers related to topics will serve as reference material
2. Vitorino, L., Bessa, L. (2017). Technological Microbiology: Development and Applications. Frot. Microbiol. 8:827. doi: 10.3389/fmicb.2017.00827.
3. Palanisamy, G., Jung, H. Y., Sadhasivam, T., Kurkuri, M. D., Kim, S. C., & Roh, S. H. (2019). A comprehensive review on microbial fuel cell technologies: Processes, utilization, and advanced developments in electrodes and membranes. *Journal of cleaner production*, *221*, 598-621.

MBEC 317	Virology and Mycology	4hrs/week	4 Credits

Unit 1: Introduction to virology and viral classification:

- Brief outline on discovery of viruses
- characteristics and structure of virus, viral genome, their types
- Nomenclature and classification of viruses
- Viral cultivation
- Assay of viruses, physical and chemical methods

Unit 2: Life cycle of virus and virus related agents

- Life cycle of viruses: Lytic and lysogenic cycle
- Decision between lytic and lysogenic cycle in bacteriophage lamda
- Structure and life cycle of Influenza virus, HIV and COVID-19
- Virus related agents

Unit 3: Studying the structure, life cycle and pathogenesis of

- Plant Viruses: TMV, CMV and Gemini virus
- Animal viruses: Rhabdo, Rota and Hepatitis
- Viruses in vaccine development

Unit 4: Mycology: Introduction

- Characteristics of fungi
- Classification of fungi
- Cultivation of fungi in laboratory
- Importance of fungi industry
- Mycotoxins

Unit 5: Important fungal associations and their applications

- Lichens: Asco-, basidio- and deuteron-
- Mycorrhiza: Ecto-, endo- and ectendo-
- Fungi as insect symbionts
- Fungal biocontrol agents
- Role of fungi in biodeterioration

References:

1. Lewin, B. (2017). *Genes*. 12th Edition, Mc Graw-Hill Interamericana
2. Dimmock, N.J., Easton, A.J., Leppard, K.N.(2016). Introduction to modern virology, 7th edition. Wiley Blackwell
3. Carter, J., Saunders, V. Virology: principals and applications, 1st edition, Wiley
4. Flint, S.J., Enquist, L.W., Krug, R.M., Racaniello, V.R. Skalka, A.M. Principles of Virology (Vol. 1) and Pathogenesis and control (Vol. 2), 5th edition, ASM Press.
5. Alexopoulos, C.J. and C.W. Mims 1979. Introduction to Mycology (3rd Ed.) Wiley Eastern Ltd., New Del
6. Charlile M. & Watkinson S.C. The Fungi, Publisher: Academic Press.
7. E.Moore –Landeekeer: Fundamentals of the fungi, Publisher: Prentice Hall.
8. Burnett J.H., Publisher: Edward, Arnold Crane Russak: Fundamentals of Mycology

MBEC 318	Combined Practicals	12hrs/week	6 Credits

Compulsory Practicals

1. Studies of public domain databases for nucleic acid and protein sequences.
2. Determination of protein structure (PDB)
3. Genome sequence analysis
4. Slide and tube agglutination test for Typoid
5. DOT ELISA test for HIV
6. Slide preparation for visualization of malarial parasite

Elective Practical

Food and Dairy Microbiology / Agriculture Microbiology

1. Efficiency of pasteurization and sterilization of milk by Phosphatase Test.
2. Preparation of Cheese, sauerkraut by microbial fermentation process.
3. Isolation of *Aspergillus flavus* and detection of aflatoxin from infected peanuts.

OR

1. Isolation of Phosphate solubilizing microorganisms
2. Isolation and Study of PGPR attributes of soil microorganisms
3. Production of liquid bio-fertilizers

Elective Practical

Advanced Molecular Techniques:

1. Southern blotting
2. Western blotting
3. Protein structure retrieval and visualization

Elective Practical

Virology and Mycology / Microbial Technology

1. One step growth experiment
2. DNA isolation from bacteriophage
3. Mushroom cultivation

OR

1. Construction of a Biofuel cell
2. Determination of 5 day BOD
4. Study of algal bloom: oxygen levels, total organic carbon and bacterial count

MBCC 419	Biostatistics and Research Methodology	4hrs/week	4 Credits

Unit –1 Introduction to Biostatistics

- Basic definitions and applications.
- Sampling: Representative sample, sample size, sampling biasand sampling techniques.
- Data collection and presentation: Types of data, methods of collection of primary and secondary data,
- Methods of data presentation, graphical representation by histogram, polygon, ogive curves and pie diagram.

Unit –2 Measures of central tendency

- Measures of central tendency: Mean, Median, Mode.
- Measures of variability: Standard deviation, standard error, range, mean deviation and coefficient of variation.
- Correlation and regression: Positive and negative correlation and calculation of Karl Pearsons co-efficient of correlation.
- Linear regression and regression equation and multiple linear regression, ANOVA, one and two way classification.
- Calculation of an unknown variable using regression equation.

Unit – 3 Tests of significance

- Tests of significance: Small sample test (Chi-square t test, F test), large sample test (Z test) and standard error.
- Introduction to probability theory and distributions, (concept without deviation) binomial, poison and normal (only definitions and problems)
- Computer oriented statistical techniques. Frequency table of single discrete variable, bubble spot, computation of mean, variance and standard
- Deviations, t test, correlation coefficient

UNIT III– Research methodology

- Characteristics and types of scientific research
- Basics of research methodology
- Research and Experimental design
- Method of Data collection

UNIT IV– Scientific deliveries

- Scientific Deliveries and Communications: Writing Research proposal, Paper, Thesis, Report and Citations Citations, H-Index, I10-Index, Impact factor and selection criteria of scientific journals for research publications
- Presenting scientific research: Power point presentations, Posters, Flyers, etc.
- Publication processes, Review Processes and Significance of scientific communications

References:

1. Statistics in biology, Vol. 1 by Bliss, C.I.K. (1967) Mc Graw Hill, NewYork.
2. Practical Statistics for experimental biologist by Wardlaw, A.C. (1985).
3. Statistical Methods in Biology - 2000 by Bailey, N.T. J. English Univ. Press.
4. Biostatistics - 7th Edition by Daniel
5. Fundamental of Biostatistics by Khan
6. Biostatistical Methods by Lachin
7. Statisticsfor Biologist by Campbell R.C. (1974) Cambridge University Press, UK.

8. Day R.A. 7th Edition. How to write and publish a scientific paper
9. Raiyani, Jagdish R. (2012). Research Methodology: Theory and Teachniques. New Century Publications ISBN: 9788177082944
10. Kothari, C. R., Garg, Gaurav. (2019). Research Methodology: Methods and Techniques. (4 th ed.) New Age International Publishers, New Delhi, ISBN: 9386649225

MBCC 420	**(Dissertation/ Project work/ Industrial Training)**	36	18

The purpose of this exercise is to become familiar with research methods, computer application, literacy and the presentation skills. All viewpoints must be addressed in your outline and project. The student has the freedom to select any research problem related to Microbiology; they can also work for their masters' thesis in the department or research institutes or industry with prior communication and approval from both the side. The duration of training will be 4 months (16 weeks) immediately after the completion of practical and theory examination of Semester II. The students will be called for one presentation of work done by them duly endorsed by the Industry / Institution guide at the completion of one month of training. At the end of two months they shall have to study two papers. During this they shall have to present the second presentation of industrial / intuitional training and there after submit a detailed report before the start of the semester IV examination.

1. Select any problem/ Research Problem in consultation with the faculty for proper guidance.
2. Learn what resources are available and how to access them
3. Collect references, secondary information on the topic and prepare bibliography
4. Set the methodology, approve it from faculty/supervisor and proceed for field and experimental work.
5. Collect findings Record Results (statistics/data tables)
6. Interpret and explain results (using charts)
7. Conclusion and preparation of detailed report/thesis
8. Use outline and related research for presentation of your work.

The outline must include the following:

- For guidelines and format/ consult faculty.
- Literature Review section should include citations and/or references from previous studies of the topic
- References must be taken from a book, journal, newspaper and Internet.
- Make certain that your cited sources are in APA Citation Style.

A 15-minute formal oral presentation during the final examination

Two presentations of 200 marks each shall be evaluated and from it marks will be considered for internal evaluation.

Total Marks : 600
Internal Marks : 200 Dissertation: 400 marks