MB 611 MJ: Immunology
Major Core Theory Paper
Total: 4 Credits | Workload: 15 hrs/credit
(Total Workload: 4 credits × 15 hrs = 60 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Define cell surface receptors and terminologies used in tumor immunology, as well as list properties of immune receptor-ligand interactions, components of signal transduction, BRMs and tumors of the lymphoid system
CO 2	Explain signal transduction pathways and the role of adhesion molecules in immune activation, mechanisms of tolerance induction, cytokine-mediated cross-regulation of TH subsets, *in vivo* systems and escape mechanisms of tumor from host defence
CO 3	Apply the use of BRMs for therapy
CO 4	Compare regulation of complement system by classical and alternative pathways, as well as differentiate between tumor antigens
CO 5	Understand immunotherapy approaches and applications to treat cancer and infections
CO 6	Summarise the concept of network theory

MB 611 MJ: Immunology
Major Core Theory Paper
Total: 4 Credits | Workload: 15 hrs/credit
(Total Workload: 4 credits × 15 hrs = 60 hrs in semester)

Credit	Credit Title and Contents	No. of Hours
I	**Cell Surface Molecules and Receptors** A. General Properties of Immune Receptor-Ligand Interactions: 1. Noncovalent interactions 2. Strength of receptor-ligand interactions B. Structure and Role of the Following Receptors: 1. B cell receptor 2. TCR-CD3 complex 3. Pattern recognition receptor (TLR) 4. Cytokine receptors 5. G-protein coupled receptors C. Role of Adhesion Molecules in Immune Activation with Respect to T Cell Activation D. Common Features of the Cell Signalling Pathways: 1. Ligand binding causing dimerization of receptors 2. Ligand binding inducing phosphorylation of tyrosine residues in receptors and role of intracellular adapter proteins 3. Signal transduction pathways: IL-2 pathway (JAK/STAT, Ras/MAP kinase pathways, TCR-CD3 activation pathway)	15
II	**Regulation of Immune Response** 1. Immunological tolerance (central and peripheral), mechanisms of tolerance induction (related experimentation using transgenic animals), T cell mediated suppression of immune response (T reg cells) 2. Regulation of immune responses by antigen, antigen-antibody complexes 3. Niels Jerne's immune network theory and its experimental evidence 4. Cytokine mediated cross regulation of TH subsets (TH1-TH2)	15

	5. Regulation of complement system- classical and alternative pathway 6. Biological response modifiers for cancer therapy	
III	**Experimental Immunology** In Vitro Systems- Quantification Of Cytokines (Elispot Assay), Functional Assays For Phagocytes And Cytokines (Flow Cytometry, Cytotoxicity And Growth Assays) Cell Analysis Methods: Tritiated Thymidine ([3H] Thymidine) Uptake Method, Mtt Assay, Assays Of Cell Death: The 51Cr Release Assay , Comet Assay In Vivo Systems- Ethical Issues Regarding the Use of Experimental Animals, Experimental Animals In Immunology Research: Inbred Animal Strains, Knockout Mice, Transgenic Animals, Syngenic Mice, Nude Mice, Animal Models For Autoimmunity and Aids	15
IV	**Tumor Immunology** A. Definition Of Terms: Neoplasm, Malignancy, Metastasis, Transformation, Angiogenesis And Oncogenes. B. Classification Of Tumors, Cellular Transformations During Neoplastic Growth, Tumors Of Lymphoid System (Lymphoma, Myeloma, Hodgkin's Disease And Non-Hodgkin's Lymphoma) C. Tumor Antigens: Tumor-Specific Antigens And Tumor-Associated Antigens With Examples. D. Escape Mechanisms Of Tumors From Host Defence, Host Immune Response To Tumor (Effectors Mechanisms) And Immuno Surveillance Theory And Immunoediting. E. Diagnosis Of Tumors – Biochemical And Immunological Tumor Markers. F. Approaches In Cancer Immunotherapy: Immune Adjuvant And Tumor Vaccine Therapy ,Car T Cell Therapy	15

Suggested References for MB 611 MJ: Immunology Major Core Theory Paper	
Credit	**References**
I	**Cell Surface Molecules and Receptors** 1. Austyn J. M. and Wood K. J. (1993). Principles of Molecular and Cellular Immunology. First edition Oxford University Press, New York. 2. Barret J. T. (1983). Text Book of Immunology. Fourth edition. Saint Louis, Mosby, London. 3. Boyd W. C. (1966). Fundamentals of Immunology, Interscience Publishers, New York. 4. Gangal S. and Sontakke S. (2013). Textbook of Basic and Clinical Immunology. University Press, India. 5. Garcia K. C. and Adams E. J. (2005). How the T cell Receptor Sees Antigen- A Structural View. Cell. 122(3): 333–336. 6. Hafler D. A. (2007). Cytokines and interventional immunology, Nature Reviews, Immunology. 7(6): 423-423. 7. Kindt T. J., Osborne B. A. and Goldsby R. A. (2006). Kuby Immunology, Sixth edition, W. H. Freeman & Co. 8. Owen Judith A,Punt Jenni, Stranford Sharon A and Jones Patricia P.(2013) Kuby Immunology.Seventh Edition.W. H. Freeman and Company. 9. Punt Jenni, Stranford Sharon A, Jones Patricia P and Owen Judith A. (2019) Kuby Immunology.Eighth Edition.W.H. Freeman and Company. 10. Yoshimura A., Naka T. and Kubo M. (2007). SOCS proteins, cytokine signalling and immune regulation. Nature Reviews, Immunology, 7(6): 454-465
II	**Regulation of Immune Response**

	1. Abbas A. K. and Lichtman A. H. (2004). Basic Immunology. Functions and Disorders of Immune System. Second edition. Elsevier Inc. 2. Carroll M. C. (2004). The complement system in regulation of adaptive immunity. Nature Immunology. 5(10): 981-986. 3. Kindt T. J., Osborne B. A. and Goldsby R. A. (2006). Kuby Immunology. Sixth edition. W. H. Freeman & Co 4. Patwardhan B., Gautam M. and Diwanay S. (2006). Botanical immunomodulators and chemoprotectants in cancer therapy. In Drug Discovery and Development Volume I: Drug Discovery. Ed. Chorghade Mukund S. Wiley- Interscience, John Wiley and Sons Inc. USA. 405-424. 5. Roitt Ivan M and Delves Peter J.(2001) Roitt's Essential Immunology.Tenth Edition. Blackwell Science Ltd 6. Yoshimura A., Naka T. and Kubo M. (2007). SOCS proteins, cytokine signalling and immune regulation. Nature Reviews. Immunology. 7(6): 454-465
III	**Experimental Immunology** 1. Gangal S. and Sontakke S. (2013). Textbook of Basic and Clinical Immunology. University Press, India. 2. House R. V. (1998). Therapeutic Manipulation of Cytokines, Biotechnology and Safety Assessment. Second edition. Taylor & Francis. 81-105. 3. Kindt T. J., Osborne B. A. and Goldsby R. A. (2006). Kuby Immunology. Sixth edition. H. Freeman and Co. 4. Roitt I.Brostoff J. and Male D. (1993). Immunology. Sixth edition. Mosby & Co. London. 5. Owen Judith A,Punt Jenni, Stranford Sharon A and Jones Patricia P.(2013) Kuby Immunology.Seventh Edition.W. H. Freeman and Company. 6. Punt Jenni,Stranford Sharon A,Jones Patricia P and Owen Judith A.(2019) Kuby Immunology.Eighth Edition.W.H. Freeman and Company. 7. Paul W. E. (2003). Fundamental Immunology. 5th Ed. Lippincott. Williams and Wilkins Publishers. 8. Talwar G. P. (1983). Handbook of Immunology. Vikas Publishing Pvt. Ltd. New Delhi.
IV	**Tumor Immunology** 1. Bendelac A., Savage P. B. and Teyton L. (2007). The Biology of NKT Cells. Annu. Rev. Immunol. 25: 297–336. 2. Chatterjee C. C. (1992). Human Physiology Tenth edition Vol. 1 and 2. Medical Allied Agency, Calcutta. 3. Diwanay S., Gautam M. and Patwardhan B. (2004). Cytoprotection and Imunomodulation in Cancer Therapy. Current Medicinal Chemistry - Anti-Cancer Agents. 4(6): 479-490. 4. Guyton A. C. and Hall J. E. (1996). Text Book of Medical Physiology. Goel Book Agency, Bangalore. 5. Leen A. M., Rooney C. M. and Foster A. E. (2007). Improving T cell therapy for cancer. Annu Rev. Immunol. 25 (1): 243–265. 6. Malati T. (2007). Tumor Markers: An Overview, Indian Journal of Clinical Biochemistry. 22(2): 17-31. 7. Patwardhan B. Gautam M. and Diwanay S. (2006). Botanical Immunomodulators and Chemoprotectants in Cancer Therapy. In Drug discovery and development Volume I: Drug Discovery. Ed. Chorghade Mukund S. Wiley- Interscience, John Wiley and Sons Inc. USA. 405-424. 8. Stuhler G. and Walden P. 2002. Cancer Immune Therapy - Current and Future Strategies. Wiley-VCH

MB 612 MJ: Molecular Biology II
Major Core Theory Paper
Total: 4 Credits | Workload: 15 hrs/credit
(Total Workload: 4 credits × 15 hrs = 60 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Understand the concept and applications of genomics
CO 2	Correlate the evolving science of epigenetics and functional genomics
CO 3	Understand genomic variation (Single Nucleotide Polymorphisms and aging) and gene editing techniques
CO 4	Apply knowledge of gene therapy in GMO and related issues
CO 5	Describe the various types of mobile genetic elements and their role in evolution
CO 6	Understand the concept and applications of proteomics and metabolomics

MB 612 MJ: Molecular Biology II
Major Core Theory Paper
Total: 4 Credits | Workload: 15 hrs/credit
(Total Workload: 4 credits × 15 hrs = 60 hrs in semester)

Credit	Credit Title and Contents	No. of Hours
I	**Genomics** A. Gene Sequencing Techniques: 1. Maxam & Gilbert sequencing 2. Sanger's sequencing 3. Next-generation sequencing (pyrosequencing/nanopore sequencing) B. Alternative Gene Expression: 1. Alternative splicing to produce many proteins from one gene 2. DNA imprinting with any one example 3. Epigenetics concept and mechanisms C. Genomic Variation: 1. SNPs and diseases 2. SNPs detection and therapy 3. Genetics of aging 4. Genetic trade-off mechanisms	15
II	**Genetic Engineering and Genome Editing** A. DNA Amplification Approaches and Applications: 1. Polymerase Chain Reaction (principle; types of PCR - reverse-transcription PCR, real-time PCR, colony PCR, digital droplet PCR) 2. Isothermal Amplification 3. PCR in molecular diagnostics (viral and bacterial) B. Gene Therapy and Gene Editing 1. Concepts of gene therapy and gene augmentation 2. Introduction to genome editing technologies (Zinc Finger Nucleases, conditional gene knockouts) C. Genetically Modified Organisms: 1. Methods to generate transgenic plants and animals 2. Two examples of transgenic plants - BT Cry genes in GM Corn and mAB gene in GM Tobacco	15

	3. Two examples of transgenic animals - GFP gene in GM Monkey and Gal 4 UAS system in GM *D. melanogaster* 4. Advantages and disadvantages of GMOs 5. Ethics, principles and intellectual property rights related to GMOs	
III	**Transposable Elements** A. Transposable Elements in Bacteria: 1. IS elements, composite transposons, integrons 2. Replicative and non-replicative transposons 3. Controlling elements in *Tn*A, *Tn*5 and *Tn*10 transposition B. Transposons in Maize (*Ac-Ds* System) and *Drosophila* (*P* Elements) C. Retrotransposons and *Ty* Elements in Yeasts D. Transposable Elements in Humans: 1. SINES, LINES and *Alu* elements 2. Role of transposable elements in human evolution	15
IV	**Proteomics and Metabolomics** A. Proteomics: 1. Introduction to proteomics 2. Proteome and nature of proteome 3. Application of proteomics in studying the genome, gene expression and its function 4. Steps involved in studying structural and functional proteomics 5. *In vitro* protein synthesis in bacteria 6. Study of proteome using Mass Spectrometry B. Metabolomics: 1. Basic concept of metabolomics with examples 2. Applications of metabolomics 3. Metabolons 4. Isolation of metabolites from biological systems 5. Metabolite separation and detection methods (GC, GC-MS and NMR)	15

Suggested References for MB 612 MJ: Molecular Biology II
Major Core Theory Paper

Credit	References
I	**Genomics** 1. Alwi Z. B. (2005) The Use of SNPs in Pharmacogenomics Studies. Malays J Med Sci. 12(2):4- 12. 2. Butler J. M. (2012) Single Nucleotide Polymorphisms and Applications In: Advanced Topics in Forensic DNA Typing: Methodology. Academic Press: United States.347-369 3. Lemaître J. F., Berger V., Bonenfant C., Douhard M., Gamelon M., Plard F. and Gaillard J.M. (2015) Early-late life trade-offs and the evolution of ageing in the wild. Proc Biol Sci. 7; 282(1806): 20150209. 4. Morris B. J., Willcox B. J and Donlon T.A. (2019) Genetic and epigenetic regulation of human aging and longevity. Biochim Biophys Acta Mol Basis Dis. 1; 1865(7):1718-1744. 5. Primrose S. B. and Twyman R. M. (2006) Principles of Gene Manipulation and Genomics, 7th Edition. S. B. Primrose & R. M. Twyman. Blackwell Publishing: U.S. 626 pp. 6. Ramírez-Bello J. and Jiménez-Morales M. (2017) Functional implications of single nucleotide polymorphisms (SNPs) in protein-coding and non-coding RNA genes in multifactorial diseases. Gac Med Mex. 153(2):238-250. 7. Shaw V., Bullock K. And Greenhalf W. (2016) Single-Nucleotide Polymorphism to Associate Cancer Risk. Methods Mol Biol. 1381:93-110.

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II	**Genetic Engineering and Genome Editing** 1. Cotrim A.P. and Baum B. J. (2008) Gene therapy: some history, applications, problems, and prospects. Toxicol Pathol. 36(1): 97-103. 2. Gene Therapy Tools and Potential Applications - Francisco Martin Molina (2013) Janeza Trdine 9, 51000 Rijeka, Croatia (online book) 3. Glick B. R. and Pasternak J. J. (1998) Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington D C, ASM Press. (http://library.um.edu.mo/ebooks/b28045804.pdf) 4. Weaver R. (2007) Molecular Biology. 4th Edition. Mc-Grew Hill Publication 5. Worgall S. and R. G. (2014) Gene Therapy In: Principles of Tissue Engineering (Fourth Edition). Academic Press: United States. Chapter 34. 657-686. 6. Maghari B. M. and Ardekani A.M. (2011) Genetically modified foods and social concerns. Avicenna J Med Biotechnol. 3(3):109-17. 7. Agnès E. Ricroch, Michèle Guillaume-Hofnung and Marcel Kuntz (2018) The ethical concerns about transgenic crops. Biochem J 475 (4): 803–811. 8. Ormandy E.H., Dale J. and Griffin G. (2011) Genetic engineering of animals: ethical issues, including welfare concerns. Can Vet J. 52(5):544-50 9. Andras Nagy. Cre Recombinase: The Universal Reagent for Genome Tailoring.Genesis 26:99–109 (2000) (https://dosequis.colorado.edu/Courses/MethodsLogic/papers/Cre_Recombinase_review.pdf) 10. Laura Tran. The Cre-loxP System: A Powerful Tool in the GeneticToolbox (https://www.the-scientist.com/the-cre-loxp-system-a-powerful-tool-in-the-genetic-toolbox-71499) 11. Tan M, Liao C, Liang L, Yi X, Zhou Z and Wei G (2022) Recent advances in recombinase polymerase amplification: Principle, advantages, disadvantages and applications. Front. Cell. Infect. Microbiol.12:1019071 (doi:10.3389/fcimb.2022.1019071) 13. Zanoli, L. M., & Spoto, G. (2012). Isothermal amplification methods for the detection of nucleic acids in microfluidic devices. Biosensors, 3(1), 18–43. (https://doi.org/10.3390/bios3010018)(https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4263587/) 14. Ahmad M. Khalil, The genome editing revolution: review, Journal of Genetic Engineering and Biotechnology, Volume 18, Issue 1, 2020, 68, ISSN 1687-157X, (https://doi.org/10.1186/s43141-020-00078-y) (https://www.sciencedirect.com/science/article/pii/S1687157X23005310)
III	**Transposable Elements** 1. Lewin B. (2011) Genes X. Jones and Bartlett Publication. 2. Watson J. D., Baker T. A., Gann A., Bell S. P., Levine M. and Losick R. 7th Edition. Molecular Biology of the Gene. Pearson-USA 3. Lodish H. F. (2003) Molecular Cell Biology 5Th Edition. New York: W H and Freeman Company. 4. Reddy, A.R., Peterson, P.A. Transposable elements of maize. Molec Gen Genet 192, 21–31 5. Kaminker, J.S., Bergman, C.M., Kronmiller, B. et al. (2002) The transposable elements of the *Drosophila melanogaster* euchromatin: a genomics perspective. Genome Biol 3, research0084.1 (2002).

	6. Krastanova, O, M. Hadzhitodorov & M. Pesheva (2005) Ty Elements of the Yeast Saccharomyces Cerevisiae, Biotechnology & Biotechnological Equipment, 19: sup2, 19-26 7. Griffiths AJF, Gelbart WM, Miller JH, et al. (1999) Modern Genetic Analysis. New York: W. 8. H. Freeman; Ty Elements in Yeast. (https://www.ncbi.nlm.nih.gov/books/NBK21285/) 9. Carnell A. M. and Goodman J.I. (2003) The Long (LINEs) and the Short (SINEs) of It: Altered Methylation as a Precursor to Toxicity. Toxicological Sciences. 75(2):229–235 10. Konkel M. K., Walker J. A. and Batzer M. A. (2010) LINEs and SINEs of primate evolution. Evol Anthropol. 1; 19(6):236-249. 11. Kramerov D. A. and Vassetzky N. S. (2011) Origin and evolution of SINEs in eukaryotic genomes. Heredity (Edinb). 107(6):487-95. 12. Weiner A. M. (2002) SINEs and LINEs: The art of biting the hand that feeds you. Current Opinion in Cell Biology. 14(3): 343-350 13. Yilan Wang, Boxun Zhao, Jaejoon Choi and Eunjung Alice Lee. Genomic approaches to trace the history of human brain evolution with an emerging opportunity for transposon profiling of ancient humans (2021) 12:22 (https://doi.org/10.1186/s13100-021-00250-2)
IV	**Proteomics and Metabolomics** 1. Kellner R. (2000) Proteomics: Concepts and perspectives. Fresenius J Anal Chem. 366(6-7):517-524. 2. Ekman R., Silberring J., Brinkmalm A. W. and Kraj A. (2009). Mass Spectrometry: Instrumentation, interpretation and applications, John Wiley and Sons. Inc., Canada. 2. Graves P.R. and Haystead T. A. (2002) Molecular biologist's guide to proteomics. Microbiol Mol Biol Rev. 2002 Mar;66(1):39-63. 3. Patwaradhan B. and Chaguture R. (2005) An overview of the basics of proteomics. In: Innovative approaches in drug discovery, Academic Press: United States. (https://analyticalscience.wiley.com/do/10.1002/sepspec.10201education/full/) 4. Baidoo E. E. K. (2019) Microbial Metabolomics: A General Overview. Methods Mol Biol. 1859:1-8. 5. Kathera C (2019) Microbial proteomics and their importance in Medical Microbiology. Recent Developments in Applied Microbiology and Biochemistry, 21-36. 6. Pandey A and Mann M (2000) Proteomics to study genes and genomes. Nature, 405:837. 7. Tang J. (2011) Microbial metabolomics. Curr Genomics. 12(6):391-403. 8. Villas-Bôas S. (2012) Katya Ruggiero Microbial Metabolomics CABI. 9. Webster D. (2000) Protein Structure, Prediction methods and Protocols. Methods in Molecular Biology Vol 143 Humana Press. 10. Wilson K. And Walker J. (2005) Principles and Techniques of Biochemistry and Molecular Biology, 6th Edn., Cambridge University Press, New York. 11. Banaei-Esfahani A, Nicod C, Aebersold R, Collins BC. (2017) Systems proteomics approaches to study bacterial pathogens: application to *Mycobacterium tuberculosis*. Curr Opin Microbiol. 39:64-72. 12. Chen B, Zhang D, Wang X, Ma W, et al. (2017) Proteomics progresses in microbial physiology and clinical antimicrobial therapy. Eur J Clin Microbiol Infect Dis.36(3):403-413. 13. Chen F, Ma R, Chen XL. (2019) Advances of Metabolomics in Fungal Pathogen-Plant Interactions. Metabolites. 15;9(8):169. 14. Zhao J., Wang G., Chu J. and Zhuang Y. (2019) Harnessing microbial metabolomics for industrial applications. World J Microbiol Biotechnol. 36(1):1-8. 15. Ramanathan M., Porter D.F. and Khavari P.A. (2019) Methods to study RNA-protein interactions. Nat Methods. 16(3):225-234. 16. Luger K. and Phillips S.E. (2010) Protein-Nucleic acid interactions. Curr Opin Struct Biol.20(1):70-2.

MB 613 MJ: Clinical Microbiology
Major Core Theory Paper
Total: 2 Credits | Workload: 15 hrs/credit
(Total Workload: 2 credits × 15 hrs = 30 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Understand concepts of medical microbiology
CO 2	List and describe medically important microorganisms
CO 3	Gain knowledge of morphology, cultural characteristics, biochemical tests, epidemiology, laboratory diagnosis etc. of bacterial pathogens
CO 4	Gain knowledge of morphology, cultural characteristics, biochemical tests, epidemiology, laboratory diagnosis etc. of bacteria, viral and fungal pathogens
CO 5	Understand the basics and applications of various chemotherapeutic agents
CO 6	Understand the modes of action of various chemotherapeutic agents

MB 613 MJ: Clinical Microbiology
Major Core Theory Paper
Total: 2 Credits | Workload: 15 hrs/credit
(Total Workload: 2 credits × 15 hrs = 30 hrs in semester)

Credit	Credit Title and Contents	No. of Hours
I	**Concepts of Medical Microbiology** A. Factors Determining of Microbial Pathogenicity 1. Host susceptibility 2. Host resistance 3. Presence of Bacterial virulence factors 4. Presence of host-mediated pathogenesis 5. Ability for intracellular growth 6. Molecular basis of bacterial pathogenicity (virulence gene and pathogenicity island) B. Disease Prediction Epidemiological Models 1. Epidemics and epidemiology 2. Susceptible infectious recovered (SIR model) 3. Susceptible exposed Infectious recovered (SEIR model)	15
II	**Medically Important Microorganisms** A. Microbial diseases with respect to general characters, pathogenesis, diagnosis, chemotherapy and prophylaxis: 1. *Helicobacter pylori* 2. *Mycobacterium tuberculosis*, *Mycobacterium leprae* 3. Human papilloma virus (HPV) 4. *Candida auris* B. Handling and Disposal of Infectious Material	15

Suggested References for 613 MJ: Clinical Microbiology Major Core Theory Paper	
Credit	**References**
I	**Concepts of Medical Microbiology** 1. https://www.oecdilibrary.org/docserver/9789264253018en.pdf

	2. http://library.open.oregonstate.edu/microbiology/chapter/bacterial-pathogenicity/ 3. http://textbookofbacteriology.net/pathogenesis.html 4. https://onlinelibrary.wiley.com/doi/pdf/10.1002/path.1700370204 5. https://www.ncbi.nlm.nih.gov/books/NBK8526/ 6. http://www.pathwaymedicine.org/bacterial-virulence-factors 7. Garner, M.G. & Hamilton, S.A. (2011) Principles of epidemiological modeling Rev Sci. Tech (2):407-16 (https://pubmed.ncbi.nlm.nih.gov/21961213/) 8. Hethcote, H.W (PDF) Three Basic Epidemiological Models https://www.mtholyoke.edu/ 9. Giordano, G. et al. (2020) Modelling the COVID-19 epidemic and the implementation of population-wide interventions in Italy Nature Medicine 26 855-860 (https://www.nature.com/articles/s41591-020-0883-7)
II	**Medically Important Microorganisms** 1. https://www.intechopen.com/books/mycobacterium-research-anddevelopment/virulence-factors-and-pathogenicity-of-mycobacterium 2. Delogu G., Sali M. and Fadda G. (2013). The biology of *Mycobacterium tuberculosis* infection. Mediterr J Hematol Infect Dis. 16; 5(1): e2013070. 3. Echeverria-Valencia G., Flores-Villalva S.and Espitia C.I. (2017). VirulenceFactors and Pathogenicity of Mycobacterium. Chapter 12. *Mycobacterium* - Research and Development. Editor-Wellman Ribón, IntechOpen. 4. Idowu A., Mzukwa, A., Harrison, U., Palamides P., Haas R., Mbao M., Mamdoo R., Bolon J., Jolaiya T., Smith S., Ally R., Clarke A. and Njom H.(2019). Detection of *Helicobacter pylori* and its virulence genes (cagA, dupA and vacA) among patients with gastro duodenal diseases in Chris Hani Baragwanath Academic Hospital, South Africa. BMC Gastroenterol.19:.73. 5. Jianjun S., Champion P. A. and Bigi F. (2019). Cellular and Molecular Mechanisms of *Mycobacterium tuberculosis* Virulence. Frontiers in Cellular and Infection Microbiology.9:.331. 6. Testerman T. L. and Morris J. (2014). Beyond the stomach: an updated view of Helicobacter pylori pathogenesis, diagnosis, and treatment. World J Gastroenterol. 20(36): 12781-12808. 7. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC500898 8.https://www.who.int/teams/health-product-policy-and-standards/standards-and-specifications/vaccine-standardization/human-papillomavirus 9. Martins N., Ferreira I., Barros L., Silva S. and Henriques M. (2014). Candidiasis: Predisposing factors, prevention, diagnosis and alternative treatment. Mycopathologia. 177 (5-6): 223-240 10. *Candida auris*: https://www.mdpi.com/2076-2607/9/4/807 11. *Candida auris*: https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2023.1287003/full

MB 614 MJ: Practicals Based on Immunology, Molecular Biology II and Clinical Microbiology
Major Core Practical Paper
Total: 4 Credits | Workload: 30 hrs/credit
(Total Workload: 4 credits × 30 hrs = 120 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Perform and visualize immunodiffusion and immunoelectrophoresis
CO 2	Determine antibody titer from the given sample
CO 3	Understand the principle of transformation of plasmid and perform blue-white screening
CO 4	Acquire practical knowledge of isolation of RNA from bacteria and visualization by denaturing agarose gel electrophoresis and apply the knowledge in future to prepare cDNA
CO 5	Know the databases and software tools used in genomics and proteomics for microbial identification and primer designing
CO 6	Isolate and identify different pathogenic bacteria and fungi

MB 614 MJ: Practicals Based on Immunology, Molecular Biology II and Clinical Microbiology
Major Core Practical Paper
Total: 4 Credits | Workload: 30 hrs/credit
(Total Workload: 4 credits × 30 hrs = 120 hrs in semester)

Sr. No.	Practical Title	No. of Hours
1	Quantitative estimation of antigen/antibody by single radial diffusion	
2	Quantitative estimation of antigen/antibody by rocket immuno-electrophoresis	
3	Agglutination techniques: Determination of iso-antibodies titer	
4	Isolation of RNA from bacteria and visualization by denaturing agarose gel electrophoresis	
5	Transformation of the *E. coli* with standard plasmids, visualization by blue-white screening and calculate transformation efficiency	
6	Study the process of bacterial conjugation and transfer of the gene of interest	
7	Visit to institute/industry for demonstration of ELISPOT/ CFT/FACS/animal inoculation/ western blotting	
8	Manual designing of primer for a hypothetical gene Or Designing of primer for a hypothetical gene by using primer blast softwear	
9	Study of nucleic acid sequence database and sequence retrieval - NCBI GenBank, DDBJ, EMBL etc. Or Demonstration of PCR / RT PCR in diagnosis of infectious diseases/gene isolation	
10	Isolation and identification of MDR bacterial pathogen isolated from clinical samples as per CLSI guidelines	
11	Isolation and identification of *Candida* sp.	
12	Demonstration of cultivation of viruses by egg inoculation technique with pocks and plaque detection	

Suggested References for MB 614 MJ: Practicals Based on Immunology, Molecular Biology II and Clinical Microbiology
Major Core Practical Paper

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3. Kang S.J., Lim Y.A. and Baik S.Y. (2014). Comparison of ABO antibody titers on the basis of the antibody detection method used. Ann Lab Med. 34: 300–306.
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6. Alexander D. J. and Chettle N. J. (1977) Procedures for the haemagglutination and the haemagglutination inhibition tests for avian infectious bronchitis virus. Avian Pathology. 6(1):9-17
7. Green M. R. and Sambrook J. (2018). The Hanahan Method for Preparation and Transformation of Competent Escherichia coli: High-Efficiency Transformation. Cold Spring Harb Protoc. (3): 10.
8. Griffiths A. J. F., Miller J. H., Suzuki D. T., et al. (2000). An Introduction to Genetic Analysis. 7th edition. New York: W. H. Freeman; Bacterial conjugation.
(https://www.ncbi.nlm.nih.gov/books/NBK21942/)
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MB 615 MJ: Cell Culture Techniques
Group III Major Elective Theory Paper
Total: 2 Credits | Workload: 15 hrs/credit
(Total Workload: 2 credits × 15 hrs = 30 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Gain awareness about cell culture technology
CO 2	Know the different cell culture media required for cell culture techniques
CO 3	Handle the different equipments required for cell culture techniques
CO 4	Gain knowledge of the different cell culture types
CO 5	Understand the concept of lymphoid culture preparation
CO 6	Develop expertise in culturing cells and preparation of lymphoid culture

MB 615 MJ: Cell Culture Techniques
Group III Major Elective Theory Paper
Total: 2 Credits | Workload: 15 hrs/credit
(Total Workload: 2 credits × 15 hrs = 30 hrs in semester)

Credit	Credit Title and Contents	No. of Hours
I	**Basics of Cell Culture Technology** A. Introduction to Cell Culture: 1. Definition, introduction and major developments in cell culture technology 2. Cell culture media: Basic components and types of cell culture media (natural media and artificial media) 3. Cell culture equipments B. Cell Culture and Analysis Methods: 1. Cell isolation, sub-culturing and cryopreservation of cells 2. Cell viability assay, MTT assay, flow cytometry	15
II	**Types and Applications of Cell Culture** 1. Organ culture, cell culture, histotypic culture 2. Primary cell culture: adherent cell culture, suspension cell culture 3. Secondary cell culture 4. Cell lines: finite cell line, continuous cell line 5. Techniques involved in animal cell culture 6. Cell culture systems and their applications	15

Suggested References for MB 615 MJ: Cell Culture Techniques
Group III Major Elective Theory Paper

Credit	References
I	**Basics of Cell Culture Technology** 1. Freshney R. I. (2005) Culture of Animal Cells: A Manual of Basic Technique.5th Ed. John Wiley and Sons, Inc. 2. Masters J. R. W. (2000). Animal Cell Culture – A Practical Approach. 3rd Ed. Oxford University Press. 3. Mather J. P. and Penelope E. R. (1998) Introduction to Cell and Tissue Culture Theory and Technique. Plenum Press, New York 4. Masters J. R. W. (2000). Animal Cell Culture – A Practical Approach. 3rdEd. Oxford University Press

II	**Types and Applications of Cell Culture** 1. Hernandez R. and Brown D.T. (2010) Growth and maintenance of chick embryo fibroblasts (CEF). Curr Protoc Microbiol.17:A.4I.1–A.4I.8 2. Animal and Tissue culture Manual - for the course of BT- 0312- Animal cell and tissue culture Laboratory - Department of Biotechnology, School of Engineering SRM University Kattankulathur. 3. Anju Verma, Megha Verma & Anchal Singh (2020) Animal tissue culture principles and applications. Animal Biotechnology, 269-293. 269–293.Published online 2020 Jun 26. doi: 10.1016/B978-0-12-811710-1.00012-4 4. Butler Michel (2005) Animal cell cultures: recent achievements and perspectives in the production of biopharmaceuticals. Appl Microbiol Biotechnol (2005) 68: 283–291 DOI 10.1007/s00253-005-1980-8

MB 615 MJP: Prcticals Based on Cell Culture Techniques
Group III Major Elective Practical Paper
Total: 2 Credits | Workload: 30 hrs/credit
(Total Workload: 2 credits × 30 hrs = 60 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Understand knowledge of proper handling and operations of cell culture equipments
CO 2	Differentiate live and dead cells for cell culture
CO 3	Perform cell counting and vital staining techniques
CO 4	Prepare primary and secondary cell culture
CO 5	Use software tools for analysing cultured cells
CO 6	Develop expertise in cell culture technology

MB 615 MJP: Prcticals Based on Cell Culture Techniques
Group III Major Elective Practical Paper
Total: 2 Credits | Workload: 30 hrs/credit
(Total Workload: 2 credits × 30 hrs = 60 hrs in semester)

Sr. No.	Practical Title	No. of Hours
1	Differentiation of live cells from dead cells by Giemsa stain method	
2	Separation of blood components	
3	Cell counting method to ensure the desired population of cells for culturing and testing their viability by the vital staining method	
4	Primary cell culture technique using chick embryo under aseptic conditions	
5	Development of secondary growth or established cells from primary culture by repeated subculture	
6	Analysis of cultured cells using software tools (Image J/FIGI)	

Suggested References for MB 615 MJP: Prcticals Based on Cell Culture Techniques
Group III Major Elective Practical Paper

1. Freshney R.I. (2005) Culture of Animal Cells: A Manual of Basic Technique.5th Ed. John Wiley and Sons, Inc.
2. Masters J. R. W. (2000). Animal Cell Culture – A Practical Approach. 3rd Ed. Oxford University Press.
3. Mather J. P. and Penelope E. R. (1998) Introduction to Cell and Tissue Culture Theory and Technique. Plenum Press, New York
4. Masters J. R. W. (2000). Animal Cell Culture – A Practical Approach. 3rdEd. Oxford University Press.
5. Hernandez R. and Brown D.T. (2010) Growth and maintenance of chick embryo fibroblasts (CEF). Curr Protoc Microbiol.17:A.4I.1–A.4I.8
6. Animal and Tissue culture Manual - for the course of BT- 0312- Animal cell and tissue culture Laboratory - Department of Biotechnology, School of Engineering SRM University Kattankulathur.
7. Anju Verma, Megha Verma & Anchal Singh (2020) Animal tissue culture principles and applications. Animal Biotechnology, 269-293. 269–293. Published online 2020 Jun 26. doi: 10.1016/B978-0-12-811710-1.00012-4

MB 616 MJ: Bioremediation and Biomass Utilization
Group III Major Elective Theory Paper
Total: 2 Credits | Workload: 15 hrs/credit
(Total Workload: 2 credits × 15 hrs = 30 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Define and differentiate between bioremediation, biodegradation, bioaugmentation
CO 2	Understand metabolic pathways for the degradation of xenobiotics
CO 3	Understand the genetic basis of bioremediation
CO 4	Understand the significance of measuring biomass to describe ecosystem function and assist in making land management decisions
CO 5	Implement biomass utilization technologies for various materials by using microbes
CO 6	Implement bioconversion techniques for the production of industrially important products

MB 616 MJ: Bioremediation and Biomass Utilization
Group III Major Elective Theory Paper
Total: 2 Credits | Workload: 15 hrs/credit
(Total Workload: 2 credits × 15 hrs = 30 hrs in semester)

Credit	Credit Title and Contents	No. of Hours
I	**Bioremediation** A. Definitions: Xenobiotics, Bio-remediation, Biodegradation, Bio-transformation, Biosorption, Bio-augmentation, Bio-stimulation B. Types of Bioremediation: 1. Natural bioremediation (attenuation) 2. *Ex-situ* and *in-situ* bioremediation 3. Solid phase and slurry phase bioremediation C. Overview of Biodegradation: 1. Aerobic vs. anaerobic degradation 2. Microbial basis of biodegradation (types of microorganism involved) 3. Role of key enzymes in the biodegradation of compounds (biochemical reactions with an example) - Monooxygenases, dioxygenases, cytochrome P440, laccase, azoreductases, peroxidases, lignin peroxidases, superoxide dismutases D. Biodegradation Mechanism and Applications: 1. Biodegradation of hydrocarbons, pesticides, azo-dyes, heavy metals (common biochemical pathways, microorganism involved, role of abiotic factors) 2. Environmental benefits of biodegradation 3. Introduction to the Microbial-Induced Calcium carbonate Precipitation (MICP) process and its application in heavy metal bioremediation 4. Use of genetically engineered microbes in bioremediation	15
II	**Biomass Utilization** A. Concepts in Biomass Utilization: 1. Need for measurement of biomass or production 2. Biomass sources and classification 3. Chemical composition and properties of different biomass materials 4. Biomass pre-processing: size reduction and densification 5. Microorganisms used in biomass conversion	15

	B. Biological Conversion of Biomass: 1. Biomass composting 2. Anaerobic digestion of biomass 3. Biomass hydrolysis C. Biomass Utilization Examples: 1. Utilization of starch, cellulose and lignin 2. Alcohol, fructose, and silage production with advantages of each 3. Improvisation of the processes of alcohol production 4. Improvisation of the processes of fructose production	

Suggested References for MB 616 MJ: Bioremediation and Biomass Utilization
Group III Major Elective Theory Paper

Credit	References
I	1. Glick B. R., Pasternak J. J., Cheryl L. and Patten C. L. (1998). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington D C, ASM Press 2. Jaiswal S., Singh D. K. and Shukla P. (2019). Gene Editing and Systems Biology Tools for Pesticide Bioremediation: A Review. Front Microbiol. 10:87 3. Karpouzas D. G. and Singh B. K. (2006) Microbial degradation of organophosphorus xenobiotics: metabolic pathways and molecular basis. Adv Microb Physiol. 51: 119-185. 4. Ramos J. L., González-Pérez M. M. and Caballero A., van Dillewijn P. (2015). Bioremediation of polynitrated aromatic compounds: plants and microbes put up a fight. Curr Opin Biotechnol. 16(3): 275-281. 5. Weaver R. (2007). Molecular Biology. 4th Edition. Mc-Grew Hill Publication 6. Samuel MS, Sivaramakrishna A, Mehta A. Bioremediation of p-Nitrophenol by Pseudomonas putida 1274 strain. J Environ Health Sci Eng. 2014 Feb 28;12(1):53. doi: 10.1186/2052-336X-12-53. PMID: 24581307; PMCID: PMC3996030. 7. Xu, J., Wang, B., Zhang, Wh. et al. Biodegradation of p-nitrophenol by engineered strain. AMB Expr 11, 124 (2021). (https://doi.org/10.1186/s13568-021-01284-8)
II	1. Anaerobic Biotechnology for Bioenergy Production: Principles and Application. Samir K. Khanal. Wiley-Blackwell Publishing (2008). 2. Biotechnology and Alternative Technologies for Utilization of Biomass or Agricultural Wastes, A. Chakravarthy, Oxford & IBH publishing Co., New Delhi, 1989. 3. Glick B. R., Pasternak J. J., Cheryl L. and Patten C. L. (1998). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington DC, ASM Press 4. Gupta G. V. (2016). New and Future Developments in Microbial Biotechnology and Bioengineering. Aspergillus System Properties and Applications. Elsevier Book Publication. 5. Lal P .B., Wells F. M., Lyu Y., Ghosh I. N., Landick R. and Kiley P. J. (2019). A markerless method for genome engineering in Zymomonas mobilis ZM4. Front Microbiol. 10: 2216 6. Sarris, D. andPapanikolaou S. Biotechnological production of ethanol: Biochemistry, processes and technologies. Engineering Life Sciences. 16: 307-329 7. Weaver R. (2007) Molecular Biology. 4th Edition. Mc-Grew Hill Publication

MB 616 MJP: Practicals Based on Bioremediation and Biomass Utilization
Group III Major Elective Practical Paper
Total: 2 Credits | Workload: 30 hrs/credit
(Total Workload: 2 credits × 30 hrs = 60 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Carry out the biodegradation of xenobiotics
CO 2	Perform biodegradation of plastics
CO 3	Produce biodiesel using microalgae
CO 4	Isolate bio-emulsifier-producing organisms for biodegradation application
CO 5	Use microbial biomass for biosorption of textile dyes and heavy metals
CO 6	Produce compost using agro-waste

MB 616 MJP: Practicals Based on Bioremediation and Biomass Utilization
Group III Major Elective Practical Paper
Total: 2 Credits | Workload: 30 hrs/credit
(Total Workload: 2 credits × 30 hrs = 60 hrs in semester)

Sr. No.	Practical Title	No. of Hours
1	Degradation of para-nitrophenol/azo-dye/pesticide/hydrocarbon using microorganisms (degradation of any two compounds)	
2	Low-density plastic/bioplastic degradation using bacterial isolates	
3	Biodiesel production using microalgae	
4	Isolation of bio-emulsifier-producing organisms for degradation of aromatic compounds	
5	Biosorption of textile dyes and heavy metals by using microbial biomass	
6	Production of compost by using agro-waste	

Suggested References for MB 616 MJP: Practicals Based on Bioremediation and Biomass Utilization
Group III Major Elective Practical Paper

1. Arora P. K., Srivastava A., and Singh V. P. (2014). Bacterial degradation of nitrophenols and their derivatives. J Hazard Mater. 266: 42-59.
2. Bánfalvi G and Antoni F. (1990). DNA-based diagnosis. Orv Hetil. 131(18): 953-964.
3. Kulkarni M. and Chaudhari A. (2006). Biodegradation of p-nitrophenol by *P. putida*. Bioresour Technol. 97(8): 982-988.
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MB 617 MJ: Microbial Virus Technology
Group III Major Elective Theory Paper
Total: 2 Credits | Workload: 15 hrs/credit
(Total Workload: 2 credits × 15 hrs = 30 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Demonstrate knowledge of the basics of bacteriophage technology
CO 2	Learn and understand various criteria of bacteriophage characterization
CO 3	Understand the concept of mycoviruses
CO 4	Gain knowledge about applications of mycoviruses
CO 5	Gain knowledge about applications of bacteriophages as therapeutic biocontrol agents
CO 6	Learn about the application of bacteriophages in the decontamination of water

MB 617 MJ: Microbial Virus Technology
Group III Major Elective Theory Paper
Total: 2 Credits | Workload: 15 hrs/credit
(Total Workload: 2 credits × 15 hrs = 30 hrs in semester)

Credit	Credit Title and Contents	No. of Hours
I	**Bacteriophage and Mycovirus Technology** A. Bacteriophage Isolation and Purification: 1. Sources of bacteriophages (river, intestine, lakes, tooth plaque, ponds, high-temperature environments, cockroaches, raw vegetables, activated sludge, fecal matter, sewage, soil, flies, sewage treatment plant) 2. Isolation, enumeration, enrichment and purification of bacteriophages from various environmental samples (different methods) B. Characterization of Bacteriophages: 1. Plaque morphology 2. Bacteriophage morphology - ICTV system of classification 3. Host range of bacteriophages 4. Concepts of MoI and EoP 5. Adsorption and growth kinetics of bacteriophages C. Mycoviruses - A New Dimension in Microbiology: 1. Occurrence of mycoviruses 2. Taxonomy of mycoviruses 3. Mycovirus-host interaction mechanisms 4. Mycovirus characterization techniques 5. Mycoviruses as biocontrol agents against fungal plant pathogens	15
II	**Bacteriophages as Biocontrol Agents in Various Fields** 1. Bacteriophage-based technology for the decontamination of water (drinking water, recreational water, medical wastewater) 2. Bacteriophage-based technology for pathogen control in aquatic systems 3. Bacteriophages for the biocontrol of biofilms on medical devices 4. Bacteriophage-based technology for pathogen control in poultry 5. Use of bacteriophage and its products as therapeutic agents	15

Suggested References for MB 617 MJ: Microbial Virus Technology
Group III Major Elective Theory Paper

Credit	References
I	**Bacteriophage and Mycovirus Technology** 1. Ahiwale Sangeeta (2013) Bacteriophages against enteric bacterial pathogens and their potential for bioremediation of pathogen infested water bodies. PhD thesis, University of Pune, Pune, Maharashtra 2. Forest Rohwer, Merry Youle, Heather Maughan and Nao Hisakawa (2014) Life in Our Phage World. A centennial field guide to the Earth's most diverse inhabitants. Illustrations by Leah L Pantéa and Benjamin Darby (Book) 3. Hobbs Z. and Abedon S. T. (2016) Virology Diversity of phage infection types and associated terminology: the problem with Lytic or lysogenic. Minireview. FEMS Microbiology Letters, 363, , fnw047 doi: 10.1093/femsle/fnw047, 2016 4. Ackerman H.W. (2009) Phage classification and characterization. In: Clokie MRJ, Kropinski AM (Eds) Bacteriophages: methods and protocols, Volume: Isolation, characterization and interactions, Vol. 501. Humana Press, New York, 5. Clokie M. R. J. and Kropinski A. M. Editors (2009). Bacteriophages: Methods and Protocols. Volume1: Isolation, Characterization and Interactions. Springer Book 6. Isolation, Characterization and Interactions. Springer Book Effect of bacterial growth rate on bacteriophage population growth rate, Dominik Nabergoj, Petra Modic, Ales Podgornik, Wiley Microbiology open, 2017 7. Isolation, Characterization and Interactions. Springer Book Effect of bacterial growth rate on bacteriophage population growth rate, Dominik Nabergoj, Petra Modic, Ales Podgornik, Wiley Microbiology open, 2017 8. Kutter E. and Sulakvelidze A. Editors. (2004) Bacteriophages: Biology and Applications. Edition illustrated. Publisher-CRC Press. 9. Abid, M., Khan, M., Mushtaq, S., Afzaal, S., and Haider, M. (2018). A comprehensive review on mycoviruses as biological control agent. World Journal of Biology and Biotechnology, 3(2), 187-192. 10. Abbas J. (2016) A Review Paper Mycoviruses. Journal of Plant Pathology and Microbiology. 7 (12): 1-4 11. Zoll J., Verweij P. E. and Melchers W. J. G. (2018) Discovery and characterization of novel *Aspergillus fumigatus* mycoviruses. PLoS ONE 13(7): e0200511. 12. Niu Y., Yongze Yuan Y., Mao J., Yang Z., Cao Q., Zhang T., Wang S. and Liu D. (2018) Characterization of two novel mycoviruses from *Penicillium digitatum* and the related fungicide resistance analysis. Scientific Reports. 8:5513 13. Kondo H., Chiba S., Toyoda K. and Suzuki N. (2013).Evidence for negative-strand RNA virus infection in fungi. Virology, 435: 201–209 14. Balan A. and Padilla G. (1997) New thermal inducible phages isolated from tropical soils. Brazilian Journal of Genetics. 20: 4 15. Nabergoj D., Modic P. and Podgornik A. (2018). Effect of bacterial growth rate on bacteriophage population growth rate. Microbiology Open, 7, e00558. 16. Marei E.M. and Elbaz R.M. (2013) Isolation and molecular characterization of three virulent actinophages specific for *Streptomyces flavovirens*. Journal of Virology Research. 2(1):12-17 17. McLaughlin M.R. and Brooks J.P. (2008) EPA worst case water microcosms for testing phage biocontrol of *Salmonella*. J Environ Qual. 37: 266-271 18. Coy S. R., Gann E. R., Pound H. L., Short S. M. and Wilhelm S. W. (2018) Viruses of eukaryotic algae: Diversity, Methods for detection and future directions.Viruses.10: 487. 19. Lanning S. and Williams S.T. (1982) Methods for the direct isolation and enumeration of Actinophages in soil. Journal of General Microbiology,
II	**Bacteriophages as Biocontrol Agents in Various Fields** 1. McLaughlin M. R. and Brooks J. P. (2008) EPA worst case water microcosms for testing phage biocontrol of *Salmonella*. J Environ Qual. 37: 266-271

2. Sharma S., Soumya Chatterjee S., Datta S., Rishika Prasad R., Dubey D., Prasad R. K. and Vairale M.G. (2017) Bacteriophages and its applications: an overview. Folia Microbiol. 62(1):17-55
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14. Ahiwale S.S. (2011) In vitro management of hospital *Pseudomonas aeruginosa* biofilm using indigenous T7-like lytic phage. Curr. Microbiology. 62:335-340
15. Ahiwale S.S. (2011) *In vitro* management of hospital *Pseudomonas aeruginosa* biofilm using indigenous T7-like lytic phage. Curr. Microbiology. 62:335-340
16. Vinod M. G., Shiva M. M., Umesha K. R., Rajaveera B. C., Krohne G. and Karunasagar J. (2006) Isolation of *Vibrio harveyi* bacteriophage with potential for biocontrol of luminous vibriosis in hatchery environments. Aquaculture. 55: 117-124

MB 617 MJP: Practicals Based on Microbial Virus Technology
Group III Major Elective Practical Paper
Total: 2 Credits | Workload: 30 hrs/credit
(Total Workload: 2 credits × 30 hrs = 60 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Gain awareness about bacteriophage technology
CO 2	Understand different criteria for bacteriophage characterization
CO 3	Demonstrate, learn and understand the basics of bacteriophage technology
CO 4	Understand the concepts of bacteriophage growth kinetics
CO 5	Analyse and interpret bacteriophage growth kinetics
CO 6	Demonstrate bacteriophage applications in various fields

MB 617 MJP: Practicals Based on Microbial Virus Technology
Group III Major Elective Practical Paper
Total: 2 Credits | Workload: 30 hrs/credit
(Total Workload: 2 credits × 30 hrs = 60 hrs in semester)

Sr. No.	Practical Title	No. of Hours
1	Isolation and enumeration of lytic bacteriophages from various environmental samples (phages specific for *E. coli*/*Salmonella* spp./*Klebsiella* spp.)	
2	Growth kinetics experiments for coliphages (adsorption kinetics and one-step growth curve experiment)	
3	Preparation of liquid- and powder-based formulations of coliphages and study of shelf life of phage formulations	
4	Use of phage formulation for biocontrol study (any one of the following): a. *In-vitro* use of lytic bacteriophages for decontamination of water sample (microcosm study) b. *In-vitro* use of lytic bacteriophages specific against *Klebsiella* spp. for prevention and dispersion of biofilm (microtitre plate assay)	

Suggested References for MB 617 MJP: Practicals Based on Microbial Virus Technology
Group III Major Elective Practical Paper

1. Ahiwale Sangeeta (2013) Bacteriophages against enteric bacterial pathogens and their potential for bioremediation of pathogen infested water bodies. PhD thesis, University of Pune, Pune, Maharashtra
2. Forest Rohwer, Merry Youle, Heather Maughan and Nao Hisakawa (2014) Life in Our Phage World. A centennial field guide to the Earth's most diverse inhabitants. Illustrations by Leah L Pantéa and Benjamin Darby (Book)
3. Hobbs Z. and Abedon S. T. (2016) Virology Diversity of phage infection types and associated terminology: the problem with Lytic or lysogenic. Minireview. FEMS Microbiology Letters, 363, , fnw047 doi: 10.1093/femsle/fnw047, 2016
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6. Clokie M. R. J. and Kropinski A. M. Editors (2009). Bacteriophages: Methods and Protocols. Volume1: Isolation, Characterization and Interactions. Springer Book

7. Ahiwale S.S. (2011) In vitro management of hospital Pseudomonas aeruginosa biofilm using indigenous T7-like lytic phage. Curr. Microbiology. 62:335-340
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10. McLaughlin M.R. and Brooks J.P. (2008) EPA worst case water microcosms for testing phage biocontrol of Salmonella. J Environ Qual. 37: 266-271
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MB 618 MJ: Clinical Microbiology and Parasitology
Group III Major Elective Theory Paper
Total: 2 Credits | Workload: 15 hrs/credit
(Total Workload: 2 credits × 15 hrs = 30 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Understand the basic principles of collection, transport, preservation and processing of various human clinical specimens
CO 2	Gain awareness about biosafety in the laboratory concerning clinical specimen handling
CO 3	Understand the importance of bioethics in clinical microbiology
CO 4	Understand concepts of medical parasitology
CO 5	Know the etiology, pathogenesis, and clinical diagnosis of bacterial pathogens and parasites
CO 6	Gain knowledge of identifying parasites from stool specimens

MB 618 MJ: Clinical Microbiology and Parasitology
Group III Major Elective Theory Paper
Total: 2 Credits | Workload: 15 hrs/credit
(Total Workload: 2 credits × 15 hrs = 30 hrs in semester)

Credit	Credit Title and Contents	No. of Hours
I	**Clinical Microbiology** A. Clinical Specimen Handling and Acquired Infections: 1. Collection, transport, preservation and processing of various human clinical specimens in the laboratory. 2. Specimen culturing, identification and antimicrobial susceptibility testing 3. Molecular diagnosis and typing methods 4. Handling and disposal of infectious material. 5. Post-transplantation infection 6. Laboratory-acquired infections 7. Transfusion-transmitted infections 8. Antimicrobial stewardship B. Etiology, Pathogenesis, and Clinical Diagnosis of the Following Pathogens: 1. *Listeria Monocytogens* 2. *Burkholderia cepacian* 3. *Chlamydiae species* C. Bioethics: 1. Ethical implications of biotechnological products and techniques 2. Social and ethical implications of biological weapons	15
II	**Parasitology** A. Introduction to Medical Parasitology: 1. Classification of parasites 2. Host-parasite relationships 3. Routes of infection 4. Effect of parasites on organs and tissues 5. Host response to parasite infections 6. Zoonoses B. Identification of Parasites in Stool: 1. Gross examination of stool 2. Microscopic examination for the presence of parasites	15

	3. Concentration methods C. Etiology, Pathogenesis, and Clinical Diagnosis of the Following Parasites: 1. Protozoan parasites: *Leishmania donovani*, *Trypanosoma brucei gambiense* 2. Cestodes: *Taenia saginata* 3. Trematodes: *Schistosoma haematobium* 4. Nematode: *Wuchereria bancrofti*	

Suggested References for MB 618 MJ: Clinical Microbiology and Parasitology Group III Major Elective Theory Paper	
Credit	**References**
I	**Clinical Microbiology** 1. Alberts, B., Hopkin, K., Johnson, A. D., Morgan, D., Raff, M., Roberts, K. & Walter, P. (2018). Essential Cell Biology. 5th Ed. WW Norton & Company. United States of America. 2. Bisen, P. S. (2014). Laboratory protocols in applied life sciences. United Kingdom: CRC Press. 3. Apurba S. Sastry and Sandhya Bhat. Essentials of Medical Microbiology, Jaypee 4. Moselio Schaechter, Cary Engleberg, N.Barry I. Eisenstein, Gerald Medoff. Mechanisms of microbial disease, 3rd Ed, Lippincott Williams & Wilkins, 1999. 6. Samuel Baron. Medical Microbiology, 2nd Ed, Addison – Wesley Publication & Co., New York. 1986. 7. E. Joan Stokes, M.W.D. Wren, G.L. Ridgway, Clinical Microbiology 7th Ed. Hodder Arnold Publishers 7th Edition
II	**Parasitology** 1. Ananthanarayan & Paniker's Textbook of Microbiology, 8th Ed., Orient Longsman, India; 2009. 2. Bailey and Scott's Diagnostic Microbiology 9th Ed. C V Mosby, St. Louis, 2003. 3. Brooks, Geo F Jawetz Medical Microbiology 22nd Ed. Mc Grew Hill 2001. 4. Coller, Leslie Topley and Wilson's Microbiology and microbial infections Vol 1, 2, 3, 4, 5, 6, 7: 9th Ed.

MB 618 MJP: Practicals Based on Clinical Microbiology and Parasitology
Group III Major Elective Practical Paper
Total: 2 Credits | Workload: 30 hrs/credit
(Total Workload: 2 credits × 30 hrs = 60 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Collect and transport various clinical specimens
CO 2	Preserve clinical specimens for diagnosis
CO 3	Dispose contaminated materials as per biosafety guidelines
CO 4	Isolate and identify human bacterial pathogens
CO 5	Stain and identify gut parasites
CO 6	Use a micrometry slide for measurements of size of microorganisms

MB 618 MJP: Practicals Based on Clinical Microbiology and Parasitology
Group III Major Elective Practical Paper
Total: 2 Credits | Workload: 30 hrs/credit
(Total Workload: 2 credits × 30 hrs = 60 hrs in semester)

Sr. No.	Practical Title	No. of Hours
1	Study of SOPs for collection, transport and preservation techniques of human clinical samples (stool, urine, blood, sputum, biopsy, soil, and parasites)	
2	Disposal of contaminated materials	
3	Isolation and Identification of the following human bacterial pathogens (any two): *Listeria* species, *Burkholderia* species, *Chlamydiae* species	
4	Identification and study of pathogenicity and diagnosis of parasites (any two) using permanent slides or photographs: *Leishmania* sp., *Wuchereria* sp., *Taenia* sp., *Trypanosoma* sp., *Schistosoma* sp.	
5	Smear preparation, staining and identification of gut parasites from fecal content	
6	Measurements of dimensions of any two parasitic specimens using micrometry	
7	Visit to a Pathology Laboratory that processes clinical specimens to understand specimen handling and diagnostic procedures	

Suggested References for MB 618 MJP: Practicals Based on Clinical Microbiology and Parasitology
Group III Major Elective Practical Paper

1. Bisen, P. S. (2014). Laboratory protocols in applied life sciences. United Kingdom: CRC Press.
2. Forbes B. A., Sahm D. F. and Weissfeld A. S. (2007). Bailey & Scott′s Diagnostic Microbiology, 12th ed. ISBN-13: 978-0-323-01678-0
3. Ananthanarayan & Paniker's Textbook of Microbiology, 8th Ed., Orient Longsman, India; 2009.
4. Moselio Schaechter, Cary Engleberg, N.Barry I. Eisenstein, Gerald Medoff. Mechanisms of microbial disease, 3rd Ed, Lippincott Williams & Wilkins, 1999.

MB 610 RP: Minor Research Project
Preparation and Presentation of Project Proposal
Total: 4 Credits | Workload: 30 hrs/credit
(Total Workload: 4 credits × 30 hrs = 120 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Read and understand literature related to a specific topic; Use various referencing tools and databases
CO 2	Critically analyze data available in the literature
CO 3	Formulate scientific questions, and propose appropriate hypotheses, supporting objectives, and methodologies to answer the scientific questions
CO 4	Present their perspective by writing review articles
CO 5	Independently design the plan of work for experiments to be performed to achieve the given set of objectives
CO 6	Interpret, discuss and communicate scientific project proposals in written form

MB 610 RP: Minor Research Project
Preparation and Presentation of Project Proposal
Total: 4 Credits | Workload: 30 hrs/credit
(Total Workload: 4 credits × 30 hrs = 120 hrs in semester)

Course Objectives:

1. To help students organize ideas, reference material and objectives for their dissertation
2. To introduce students to the concepts of literature review to identify research gaps
3. To develop a rationale, formulate a scientific question and propose a hypothesis for the research
4. To prepare a detailed plan (project proposal) to execute the research project

Course Content:

1. Selection of Research Lab/Institute (Optional) and Research Topic:
   Students will begin the preliminary work on their dissertation project to be carried out in Semester IV. Students (in pairs or individually) will first select a lab/institute wherein they would like to pursue their dissertation project. Students (individually or in pairs) will be asked to choose relevant research topics in consultation with their respective dissertation supervisor (departmental or external if planning work in another lab/institute). The supervisors will help the students read research articles in the areas of interest of the lab/institute and guide them to select a topic for their dissertation project. The topic of the research should be hypothesis-driven.
2. Review of Literature:
   Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data, keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources. Students will write a literature review based on the chosen topic by referencing relevant literature.
3. Writing Project Proposal:
   With the help of their supervisors, the students will be able to discuss the research questions, goals, approach, methodology, data collection, etc. Students will be able to construct a logical outline for the project including analysis steps, plan of work and expected outcomes. Finally, students will prepare a complete proposal in scientific proposal format for their proposed dissertation project
4. Project Proposal Submission and PowerPoint Presentation:
   Students will submit a printed copy of their project proposal for internal assessment. Students will also prepare a PowerPoint presentation of their project proposal for presentation during the final

evaluation. During the presentation, the students will explain their chosen topic, brief literature review, their proposed plan of work, along with expected outcomes in detail.

MB 621 MJ: Pharmaceutical Microbiology
Major Core Theory Paper
Total: 4 Credits | Workload: 15 hrs/credit
(Total Workload: 4 credits × 15 hrs = 60 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Understand the basic concepts and terminologies in medicinal chemistry
CO 2	Perceive the knowledge of all the steps involved in the designing of a drug
CO 3	Know the role of the national and international regulatory sources in medicinal chemistry
CO 4	Understand the science of pharmacodynamics and pharmacokinetics
CO 5	Apply concepts and significance of technology in chemotherapy
CO 6	Gain knowledge and concepts of Clinical trials

MB 621 MJ: Pharmaceutical Microbiology
Major Core Theory Paper
Total: 4 Credits | Workload: 15 hrs/credit
(Total Workload: 4 credits × 15 hrs = 60 hrs in semester)

Credit	Credit Title and Contents	No. of Hours
I	**Introduction** 1. Definition and explanation of terms used in medicinal chemistry (HITS, lead compound, toxicity studies, High Throughput Screening) 2. Nomenclature of drugs: Introduction to IUPAC, generic system, international non-proprietary names and trade names 3. Historical perspectives: Overview of development in medicinal chemistry in 20^{th} and 21^{st} century; Significance of medicinal chemistry 4. Introduction to modern drug discovery; Rational drug design, Molecular modeling, Use of gene and DNA technology in chemotherapy 5. Classification of drugs based on therapeutic classes, targets and mechanisms of action	15
II	**Drug Development** A. Lead Optimization: 1. Lead likeness, drug likeness 2. Determination of biological and biochemical properties of drug 3. Pharmacovigilance B. Drug Designing: 1. CADD, LBDD, SBDD (protein crystallography; molecular docking) C. Drug Development: 1. Preclinical development 2. Toxicity testing – acute, sub acute, chronic D. Clinical Development: 1. Clinical trials (aims, objectives and conduct) 2. Clinical trial phases 0, I, II, III and IV	15
III	**Biopharmaceuticals** 1. Regulations and Sources 2. Regulatory authorities and its role: Food and Drug Administration (FDA), World Health Oganisation (WHO) and Clinical and Laboratory Standards Institute (CLSI) 3. Introduction to pharmacopeia: IP, USP and BP (vision, mission, policy role	15

	and objectives) 4. Significance of IP with any one example in detail 5. Ministry of AYUSH in biopharmaceutics (introduction, role and guidelines)	
IV	**ADME (Pharmacodynamics and Pharmacokinetics)** A. Passage of Molecules through Biological Barriers: 1. Membrane transport (paracellular, transcellular) B. Drug Absorption: 1. Drug dosages 2. Gastric emptying to gastric permeability to drug 3. First pass effect 4. Bioavailablity C. Drug Distribution: 1. Drug-plasma/serum binding 2. Blood brain barrier 3. Accumulations in various organs and tissues D. Drug Metabolism and Elimination: 1. Biotransformation reactions 2. Functionalization 3. Conjugation reaction 4. Reactions leading to toxic metabolites	15

Suggested References for MB 621 MJ: Pharmaceutical Microbiology Major Core Theory Paper	
Credit	**References**
I	**Introduction** 1. Agarwal S. S. and Paridhavi M. (2007) Herbal drug technology. Universities Press (India) Pvt. Ltd 2. Altreuter D. and Clark D. S. (1999) Combinatorial Biocatalysis: Taking the Lead From Nature. Curr. Opin. Biotechnol. 10: 130-136 3. Bentley's Textbook of Pharmaceutics, Ed. E. A. Rawlins, 8th Ed. (2002) Bailliere Tindall, London 4. Burn J. H. (1957) Principles of Therapeutics. Blackwell Scientific Pub. O. Ltd. Oxford. Chatwal G. P. (2003) Bio-pharmaceutics and Pharmacokinetics. Himalaya Publishing House, Mumbai. 5. Committee for the Purpose of Control and Supervision on Experiments on Animals (CPCSEA). www.cpcsea.com 6. Dewick P. M. (2002). Medicinal natural products: A biosynthetic approach, 2nd Ed., John Wiley and Sons 7. Erhardt P. W. (2006) Medicinal Chemistry in the New Millennium: A Glance into the Future, Ed. Chorghade M. S. in Drug discovery and Development Volume I: Drug Discovery. Wiley-Interscience, John Wiley and Sons Inc. USA. 17-102. 8. Graly J. O. and Joubert P.H. (1997) Handbook of Phase I /II clinical drug trials, CRC Press 9. Iyengar M. A. (1993) Pharmacology of Powdered Crude Drugs. Iyengar series. Manipal, India 10. Micheles P. S., Khmelnitsley Y. L., Dordick J. S. and Clark D. S., (1998), Combinatorial Biocatalysis, A Natural Approach to Drug Discovery, Trends in Biotechnol. 16(5): 210-215 11. Satoskar R. S. and Bhandarkar S. D. (1991) Pharmacology and Pharmacotherapeutics, 12th Ed., Vol. 1 and 2. Popular Prakashan, Mumbai. 12. Vyas S. P and Dixit V. R. (2002), Pharmaceutical Biotechnology, CBS Publishers and Distributors, New Delhi

II	**Drug Development** 1. Franklin T. J. and Snow G. A. (1975) Biochemistry of Antimicrobial Action. Chapman and Hall, London. 1-22 and 160-174 2. Gale E. F., Cundliffe E., Reynolds P. E., Richmond M. H. and Waring M. J. (1972) The molecular basis of antibiotic action. John Wiley and Sons. London 3. Goldstein A., Aronow L., and Kalman S. M. (1969) Principles of Drug Action. The Basis of Pharmacology. Harper international edition New York. 4. Lorian V. (1986) Antibiotics in laboratory medicine. 2nd Ed. Williams & Wilkins Publication 5. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). NCCLS: 1997. Methods for dilution antimicrobial susceptibility testing for bacteria that grows aerobically. Approved Standards M7-A4. Villanova, PA 6. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). NCCLS: 2002.Performance standards for antimicrobial susceptibility testing; 12th information supplement (M100- S1). Villanova, PA
III	**Biopharmaceuticals** 1. Blondelle S. E., Perez-Paya E. and Houghten R. A. (1996) Synthetic 2. Combinatorial Libraries: Novel Discovery Strategy for Identification of Antimicrobial Agents. Antimicrobial Agents and Chemotherapy. 1067–1071 3. Holliger M. A. (2008), Introduction to Pharmacology. 3rd Ed. CRC Press. Taylor and Francis. 4. Indian Pharmacopoeia (IP 2018). 8th Edition. Four Volumes with addendum 2019. Published by the Indian Pharmacopoeia Commission (IPC) on behalf of the Government of India, Ministry of Health and Family Welfare. 5. Kokate C. K., Purohit A. P., Gokhale A. B. (2000) Pharmacology, 4th Ed., Nirali Prakashan. 6. Micheles P. S., Khmelnitsley Y. L., Dordick J. S. and Clark D. S., (1998), Combinatorial Biocatalysis, A Natural Approach to Drug Discovery, Trends in Biotechnol. 16(5): 210-215 7. Osol A. (1980) Remington's Pharmaceutical Sciences, 16th Ed., Easton, Pennsylvania: Mack Publishing Company. 8. Satoskar R. S. and S. D. Bhandarkar (1991) Pharmacology and Pharmacotherapeutics, 12th Edition. Vol. 1 and 2. Popular Prakashan, Mumbai. 9. Vyas S. P. and Dixit V. R. (2002), Pharmaceutical Biotechnology, CBS Publishers and Distributors, New Delhi 10. Walsh G. (2006). Biopharmaceuticals: Biochemistry and Biotechnology. 2nd edition. Wiley (E-Book, 2013). 11. Yadava R and Arshathjyothi PS (2021) Development and contribution of AYUSH sector-A review. J. of Ayurveda and Integrated Medical Sciences, 6(3).
IV	**ADME (Pharmacodynamics and Pharmacokinetics)** 1. Holliger M. A. (2008) Introduction to Pharmacology. 3rd Ed. CRC Press. Taylor and Francis. 2. Kokate C. K., Purohit A. P., Gokhale A. B. (2000) Pharmacology. 4th Ed. Nirali Prakashan. 3. Micheles P. S., Khmelnitsley Y. L., Dordick J. S. and Clark D. S. (1998) Combinatorial 4. 4. Biocatalysis. A Natural Approach to Drug Discovery. Trends in Biotechnol. 16(5): 210-215

MB 622 MJ: Bioprocess Technology
Major Core Theory Paper
Total: 4 Credits | Workload: 15 hrs/credit
(Total Workload: 4 credits × 15 hrs = 60 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Understand bioprocess technology and its applications
CO 2	Learn different types of bioreactors and their designs
CO 3	Acquire knowledge about various process control methods in fermentation
CO 4	Acquaint themselves with the applications of microorganisms in different industries
CO 5	Learn concepts of IPR, ISO and SOPs
CO 6	Apply knowledge of entrepreneurship in Life Sciences to become entrepreneurs

MB 622 MJ: Bioprocess Technology
Major Core Theory Paper
Total: 4 Credits | Workload: 15 hrs/credit
(Total Workload: 4 credits × 15 hrs = 60 hrs in semester)

Credit	Credit Title and Contents	No. of Hours
I	**Bioreactor Design and Operation** Basic Components, Design and Scale-up of Fermentors: 1. Designing of bioreactors: a. Design aspects CSTRs b. Dimensional ratios of the outer shell c. Operational aspects such as working volume, baffles and impellers 2. Configuration (placement) of impellers in a vessel and different types of impellers (types of turbines and propellers and their combinations) 3. Immobilized cell reactors and air-lift reactors: Design and operation 4. Batch, fed-batch and continuous fermentors: Applications, advantages and limitations of each type	15
II	**Process Variables and Monitoring** A. Process Variables: 1. Aeration theory of oxygen transfer in bubble aeration; Oxygen transfer kinetics (Oxygen Uptake Rate – OUR, Oxygen Transfer Rate OTR, Ccrit), determination of KLa value. 2. Agitation; Functions of agitation; Flow patterns with different types of impellers; Effect of agitation and microbial biomass on KLa value a. Fermentation broth rheology and power requirements for agitation – Concept of Newtonian and non Newtonian fluids b. Effect of broth rheology on heat, nutrient and oxygen transfer c. Reynold's number, power number, aeration number: solving examples using different software programs B. Monitoring of Process Variables: 1. Use of various types of sensors and biosensors for monitoring environmental parameters (pressure, pH, temperature, DO and DCO_2) 2. Basic principles of operation, types of biosensors	15
III	**Applications of Bioprocess Technology** Upstream and Downstream Processing for the Following Microbial Metabolites: 1. Antibiotics (Rifamycin)	15

	2. Microbial enzymes (Chitinase) 3. Exopolysaccharides (Pullulan & Xanthan) 4. Immobilized cells/enzymes for bioconversion 5. Fungi in agriculture and environmental applications 6. Bio-mining: Microbial extraction of Cu, Au, U from ore and their bio-recovery 7. Probiotics and prebiotics: Fundamental aspects and health benefits	
IV	**Concepts of IPR, ISO Certification, SOP Preparation, Validation and Entrepreneurship** A. Intellectual Property Rights (IPR): 1. Basic concepts of IPR 2. Introduction to forms of IPR – Patents and Designs 3. Patents: Concepts and principles of patenting 4. Procedure of obtaining patents B. Concept of ISO Certification C. Preparation of SOPs D. Validation protocols for methods (as per WHO norms) in: 1. Quality Control 2. Process validation E. Exercises on preparation of SOPs, operation and validation for analytical methods F. Entrepreneurship 1. Concept of entrepreneurship; Scope for entrepreneurship in Microbiology/Life sciences 2. Concept of incubation centre 3. Challenges and considerations for startups and small scale industry	15

Suggested References for MB 622 MJ: Bioprocess Technology Major Core Theory Paper	
Credit	**References**
I	**Bioreactor Design and Operation** 1. BIOTOL series. (1992). Bioreactor Design and Product Yield. Butterworths Heinemann. 2. Doran P. M. (1995). Bioprocess Engineering Principles. Imprint-Academic Press. Copyright-Elsevier. 3. Lydersen B. K., D'Elia N. A. and Nelson K. M. (Eds.) (1993). Bioprocess Engineering: Systems, Equipment and Facilities. JohnWiley and Sons Inc. 4. Maiti B. R. (2018). Principles of Bioreactor Design. Publisher: Viva books 5. McDuffie N. G. (1991). Bioreactor Design Fundamentals 1st Edition, Elsevier: eBook ISBN: 9781483221083 6. Ratledge C. and Kristiansen B. eds. (2001). Basic Biotechnology. 2nd Ed. Cambridge Univ. Press. Cambridge 7. Singh L., Mahapatra D. and Yousuf A. (2019). Bioreactors: Sustainable Design and Industrial Applications in mitigation of GHG emissions. Elsevier. ISBN- 0128212640, 9780128212646
II	**Process Variables and Monitoring** 1. Aiba S., Humphrey A. E. and Millis N. F. (1982). Biochemical Engineering. Second Edition. Academic Press. 2. Chand S. (1998). Fermentation Biotechnology: Industrial Perspectives. Industrial Perspectives: Proceedings of the Symposium on Biotech Industry - a Challenge for 2005 A.D.

	-with Special Reference to Fermentations. November 4-6, 1998. Publisher: All India Biotech Association 3. Jozala A. F. (2017). Fermentation Processes. Publisher-BoD. Books on Demand. ISBN-9535129279, E-Book 9789535129271 4. Mandenius C-F. (2016). Bioreactors: Design, Operation and Novel Applications. Reprint. Publisher-John Wiley & Sons. ISBN 3527683372 E-Book- 9783527683376 5. Larroche C., Sanroman M., Du G. and Pandey A. (Editors). (2016). Current Developments in Biotechnology and Bioengineering: Bioprocesses, Bioreactors and Controls. Publisher-Elsevier, ISBN 0444636749, E- Book- 9780444636744 6. Lydersen B. K., D' Elia N. A. and Nelson K. M. (Eds.) (1993) Bioprocess Engineering: Systems, Equipment and Facilities. John Wiley and Sons Inc. 7. BIOTOL series. (1992). Operational Modes of Bioreactors Butterworths – Heinemann. 8. Stanbury P., Whitaker A. and Hall S. (2016). Principles of Fermentation Technology. 3rd Edition Imprint: Butterworth-Heinemann
III	**Microbial Fermentation Processes** 1. Arora D. K. (2005). Fungal Biotechnology in Agricultural, Food and Environmental Applications (Mycology), Marcel Dekker, Inc. New York. Basel 2. Belter P. A., Cussler E. L. and Hu W. S. (1994). Bioseparations Downstream processing for Biotechnology. John Wiley and Sons. N.Y. ISBN: 978-0- 471-12113-8 3. Crueger W. and Crueger A (1990). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Sinauer associates, Inc 4. Klegerman M. E. and Groves M. J. (1992). Pharmaceutical Biotechnology: Fundamentals and Essentials. Interpharm Press Ltd. Buffalo Grove, Illinois 5. Meshram S. U. and Shinde G. B. (2009). Applied Biotechnology. I.K. International Pvt. Ltd. 6. Mishra C. S. K. (Editor) and Pascale Champagne (Associate editor). (2009) . Biotechnology applications. I. K. International Pvt. Ltd. 7. Peppler H. J. and Perlman D. (1970). Microbial Technology. Volume 1and 2. Academic Press, New York. 8. Ponkhshe S. (1988). Management of Intellectual Property, Bhate and Ponkhshe Prakasham, Pune 9. Reed G. (Editor). Prescott and Dunn's Industrial Microbiology. 4th Ed., CBS Pub. New Delhi. 10. Van Damme E. J. (1984). Biotechnology of Industrial Antibiotics. Marcel Dekker Inc., New York. 11. Wiseman A. (1985). Topics in Enzyme and Fermentation Biotechnology. Vol. 1 and 2. John Wiley and Sons, New York
IV	**Concepts of IPR, ISO Certification, SOP Preparation, Validation and Entrepreneurship** 1. Calnan N., Redmond A. and O'Neill S. (2009). The FDA's draft process validation Guidance A perspective from industry. Process Validation Guidance. Pharmaceutical Engineering. GMP Publishing. 7(4): 1-17 2. Supplementary Training Modules on Good Manufacturing Practice. Validation WHO Technical Report Series, No.937, 2006, Annex 4. 3. Entrepreneur's Startup Best Businesses, FMCG, Household and Small Industries (A Complete Hand Book on Startup Projects) Eiri publication.

MB 623 MJP: Practicals Based on Pharmaceutical Microbiology and Bioprocess Technology
Major Core Practical Paper
Total: 4 Credits | Workload: 30 hrs/credit
(Total Workload: 4 credits × 30 hrs = 120 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Follow and appreciate protocols and practices in the laboratory as per the standards for successful practical completion
CO 2	Learn isolation and applications of microorganisms for industrial fermentation processes
CO 3	Acquire knowledge of upstream and downstream protocols in fermentation
CO 4	Determine various parameters of fermentation processes
CO 5	Learn to understand and apply protocols from Indian Pharmacopoeia
CO 6	Gain basic knowlegde of writing project proposals for entrepreneurship in Life Sciences

MB 623 MJP: Practicals Based on Pharmaceutical Microbiology and Bioprocess Technology
Major Core Practical Paper
Total: 4 Credits | Workload: 30 hrs/credit
(Total Workload: 4 credits × 30 hrs = 120 hrs in semester)

Sr. No.	Practical Title	No. of Hours
1	Preparation of project proposal for start-up/small-scale industry in Microbiology/Life Sciences	
2	Isolation of industrially important microbes (bacterial/fungal strains) producing citric acid/acetic acid or penicillin/streptomycin/tetracycline or any other suitable compound	
3	Selection and utilization of the above isolate (producing citric acid/acetic acid or penicillin/streptomycin/tetracycline or any other suitable compound) using submerged fermentation	
4	Production and recovery/purification of the above product from submerged fermentation	
5	Production and recovery/purification of bio-pigment/s using suitable bacterial/fungal culture	
6	Determination of substrate consumption rate (glucose) in batch culture using *E. coli*/*Bacillus* sp.	
7	Determination of yield coefficient of cell biomass (*E. coli*/*Bacillus* sp.) using a suitable substrate (e.g. glucose)	
8	Microbial limit testing of any cosmetic product using IP method	
9	Validation of disinfection procedure using a suitable disinfectant and any bacterial culture	

MB 623 MJP: Practicals Based on Pharmaceutical Microbiology and Bioprocess Technology
Major Core Practical Paper

1. Stanbury, P.F., Whitaker, A. and Hall, S.J. (2003) Principal of Fermentation Technology. 2nd Edition, Butterworth-Heinemann, Oxford.
2. A.H. Patel, Industrial microbiology (2008)- New Delhi: Macmillan India Ltd.
3. Casida, Lester Earl, (1968) Industrial microbiology, New York, Wiley.

4. Jayaraman J. (2004). Laboratory Manual in Biochemistry. India: New Age International (P) Limited Publishers.
5. Plummer M. and Plummer D.T. (2001). Introduction to practical biochemistry. 3rd Edition, Tata McGraw- Hill Edition.
6. Sadasivam S. and Manickam A. (2008). Biochemical methods. 3rd Edition, New Age International Publishers, India.
7. Practical Microbiology (2012). Ed. Dubey R.C. and D. K. Maheshwari, S. Chand & Company Pvt. Ltd., New Delhi.
8. Government of India, Ministry of Health. Pharmacopoeia of India (the Indian Pharmacopoeia). Delhi: Manager of Publications, 1955

MB 624 MJ: Quality Assurance and Validation in the Pharmaceutical Industry and Development of Anti-infectives from Plants
Group III Major Elective Theory Paper
Total: 2 Credits | Workload: 15 hrs/credit
(Total Workload: 2 credits × 15 hrs = 30 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Understand terminologies of various quality assurance and validation techniques in the pharmaceutical industry
CO 2	Understand the principles of various quality assurance and validation techniques in the pharmaceutical industry
CO 3	Use various techniques for quality assurance in the pharmaceutical industry
CO 4	Use various validation techniques in the pharmaceutical industry
CO 5	Develop anti-infectives from plants for use in pharmaceutical industries
CO 6	Apply different methods to test the anti-infective potential of plant extracts

MB 624 MJ: Quality Assurance and Validation in the Pharmaceutical Industry and Development of Anti-infectives from Plants
Group III Major Elective Theory Paper
Total: 2 Credits | Workload: 15 hrs/credit
(Total Workload: 2 credits × 15 hrs = 30 hrs in semester)

Credit	Credit Title and Contents	No. of Hours
I	**Quality Assurance and Validation in the Pharmaceutical Industry** A. Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in the Pharmaceutical Industry B. Quality Assurance and Quality Management in Pharmaceuticals: ISO, WHO, and US certification C. Safety in the Microbiology Laboratory D. Safety Profile of Drugs: a. Sterility Testing b. Pyrogenicity testing c. Mutagenicity and carcinogenicity testing d. Teratogenicity testing	15
II	**Development of Anti-infectives** A. Definitions: Therapeutic ratio, MIC and MBC B. Overview of Susceptibility Testing: 1. Use of liquid and solid media 2. Factors affecting susceptibility testing, CLSI guidelines 3. Diffusion methods – agar dilution technique, gradient plate techniques, E-test, Kirby Bauer method, Stokes method C. Susceptibility Testing for Following Agents: 1. Anti-mycobacterial agents 2. Anti-fungal agents 3. Anti-protozoal agents 4. Anti-viral agents	15

Suggested References for MB 624 MJ: Quality Assurance and Validation in the Pharmaceutical Industry and Development of Anti-infectives from Plants Group III Major Elective Theory Paper	
Credit	**References**
I	**Quality Assurance and Validation in the Pharmaceutical Industry** 1. Blondelle S. E., Pérez-Payá E. and Houghten R. A. (1996). Synthetic combinatorial libraries: novel discovery strategy for identification of antimicrobial agents. Antimicrobial Agents and Chemotherapy. 1067–1071 2. Holliger M. A. (2008). Introduction to Pharmacology. Third Ed., CRC Press. ISBN 9781420047417 3. Kokate C. K., Purohit A. P. and Gokhale A. B. (2000). Pharmacology, 4th Edition. Nirali Prakashan. 4. Maron D. M. and Bruce N. A. (1983). Revised methods for the *Salmonella* mutagenicity test. Mutation Research. 113: 173-215 5. Osol A. and Hoover J. E. (1975). Remington's Pharmaceutical Sciences, 15th Ed., Mack Pub. Co., Pennsylvania. 6. Vyas S. P and Dixit V. R. (2002). Pharmaceutical Biotechnology, CBS Publishers and Distributors, New Delhi
II	**Development of Anti-infectives** 1. Franklin T. J. and Snow G. A. (1975). Biochemistry of Antimicrobial Action. Chapman and Hall, London. 1-22 and 161-200. 2. Gale E. F., Cundliffe E., Reynolds P. E., Richmond M. H. and Waring M. J. (1972). The molecular basis of antibiotic action, John Wiley and Sons, London 3. Goldstein A., Aronow L., and Kalman S. M. (1969) Principles of Drug Action, The Basis of Pharmacology, Harper international edition New York. 4. Lorian V. (1986). Antibiotics in laboratory medicine. 2nd Ed, Williams & Wilkins Publication 5. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). NCCLS: 1997. Methods for dilution antimicrobial susceptibility testing for bacteria that grows aerobically. Approved Standards M7-A4. Villanova, PA. 6. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). NCCLS: 2002. Performance standards for antimicrobial susceptibility testing; 12th information supplement (M100-S1). Villanova, PA

MB 624 MJP: Practicals Based on Quality Assurance and Validation in the Pharmaceutical Industry and Development of Anti-infectives from Plants
Group III Major Elective Practical Paper
Total: 2 Credits | Workload: 30 hrs/credit
(Total Workload: 2 credits × 30 hrs = 60 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Perform sterility testing of oral pharmaceutical preparations as per IP norms
CO 2	Perform sterility testing of liquid pharmaceutical preparations as per IP norms
CO 3	Perform sterility testing of bulk pharmaceutical preparations as per IP norms
CO 4	Extract bioactive principles from plants
CO 5	Estimation of antimicrobial activity of bioactive compounds as per CLSI guidelines
CO 6	Perform qualitative detection of bioactive compounds from plants

MB 624 MJP: Practicals Based on Quality Assurance and Validation in the Pharmaceutical Industry and Development of Anti-infectives from Plants
Group III Major Elective Practical Paper
Total: 2 Credits | Workload: 30 hrs/credit
(Total Workload: 2 credits × 30 hrs = 60 hrs in semester)

Sr. No.	Practical Title	No. of Hours
1	Sterility testing of the pharmaceutical preparations as per IP: Oral preparations: antipyretic tablets or antibiotic tablets	
2	Sterility testing of the pharmaceutical preparations as per IP: Liquid preparations: water-soluble vitamin or cough syrup or ophthalmic drops	
3	Sterility testing of the pharmaceutical preparations as per IP: Bulk preparations: (any two) surgical cotton rolls/gauze/surgical sutures/disposable syringes	
4	Extraction of bioactive principles from plants and activity fractionation	
5	Estimation of its antimicrobial activity using standard guidelines (CLSI)	
6	Qualitative detection of extracted bioactive principles from plant	

Suggested References for MB 624 MJP: Practicals Based on Quality Assurance and Validation in the Pharmaceutical Industry and Development of Anti-infectives from Plants
Group III Major Elective Practical Paper

1. Holliger M. A. (2008). Introduction to pharmacology. 3rd Edition. CRC Press 38
2. Indian Pharmacopoeia. (2007). Government of India, Ministry of Health and Family Welfare. The Indian Pharmacopoeia Commission. Ghaziabad. 1:53
3. Knudsen L. F. (1949). Sample size of parenteral solutions for sterility testing. J Amer Pharm Assoc. 38: 332–337.
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6. Moldenhauer J. and Sutton S.V.W. (2004). Towards an improved sterility test. PDA J Pharm Sci Tech. 58 (6): 284–286.
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11. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). NCCLS: 1997. Methods for dilution antimicrobial susceptibility testing for bacteria that grows aerobically. Approved Standards M7-A4. Villanova, PA.
12. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). NCCLS: 2002. Performance standards for antimicrobial susceptibility testing; 12th information supplement (M100-S1). Villanova, PA

MB 625 MJ: Advances in Microbial Technology
Group III Major Elective Theory Paper
Total: 2 Credits | Workload: 15 hrs/credit
(Total Workload: 2 credits × 15 hrs = 30 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Understand the concept of kinetics of microbial growth in a bioreactor system
CO 2	Understand the concept of kinetics of product formation in a bioreactor system
CO 3	Gain knowledge of the kinetics of microbial growth during batch fermentation
CO 4	Gain knowledge of the kinetics of product formation during batch fermentation
CO 5	Appreciate the methods in solid state fermentation system and process details
CO 6	Gain knowledge of applications of solid-state fermentation for large-scale manufacturing

MB 625 MJ: Advances in Microbial Technology
Group III Major Elective Theory Paper
Total: 2 Credits | Workload: 15 hrs/credit
(Total Workload: 2 credits × 15 hrs = 30 hrs in semester)

Credit	Credit Title and Contents	No. of Hours
I	**Microbial Growth and Product Formation in a Reactor** A. Microbial Growth: 1. Concept of microbial growth and its characteristics: 2. Growth parameters - growth rate, specific growth rate, yield factor and substrate utilization constant 3. Kinetics of growth in: a. Batch culture – Monod model b. Continuous culture c. Fed-batch culture 4. Simple mathematical problems based on the determination of growth parameters in the above systems B. Kinetic Patterns of Growth and Product Formation in Batch Fermentation: 1. Growth-associated products 2. Non-growth associated products 3. Mixed growth-associated products 4. Yield coefficients and maintenance coefficients	15
II	**Advances in Solid-state Fermentation** A. Concept of Solid-state Fermentation 1. Introduction 2. List of examples in detail 3. Merits and demerits 4. Current developments B. Comparative Account of Liquid-state (surface and suspended culture) and Solid-state Fermentation in Detail C. Factors Affecting Solid-state Fermentation: 1. Inoculum type (microorganisms) 2. Moisture and water activity, pH, temperature 3. Substrate and its choice in detail, particle size 4. Aeration and agitation 5. Nutritional factors	15

	6. Oxygen and carbon dioxide D. Bioreactors in Solid-state Fermentation (only designs and operation): 1. Tray and packed-bed bioreactors 2. Constantly moving, fluidized bed, gliding, and agitated bioreactors. E. Challenges in Solid-state fermentation: Heat and mass transfer, growth and modeling of microorganisms F. Large-scale manufacturing using SSF (case study from research articles) for: 1. Animal feed 2. Industrial enzyme – Cellulase	

Suggested References for MB 625 MJ: Advances in Microbial Technology Group III Major Elective Theory Paper	
Credit	**References**
I	**Microbial Growth and Product Formation in a Reactor** 1. Stanbury P. F. (2009). Principles of Fermentation Technology, 2nd Edition, Elsevier 2. Najafpour, G. D. (2007). CHAPTER 5 - Growth Kinetics. In G. D. Najafpour (Ed.), Biochemical Engineering and Biotechnology (pp. 81-141). Amsterdam: Elsevier. 3. Syed Tanveer Ahmed Inamdar (2012). Biochemcial Engineering: Principles and Concepts, 3rd Edition, PHI Learning Private Limited, New Delhi
II	**Advances in Solid-state Fermentation** 1. Panday A. (2009). Solid state fermentation, New Age International publishers. 2. Ge, X., Vasco-Correa, J., & Li, Y. (2017). 13 - Solid-State Fermentation Bioreactors and Fundamentals. In C. Larroche, M. Á. Sanromán, G. Du & A. Pandey (Eds.), Current Developments in Biotechnology and Bioengineering (pp. 381-402): Elsevier. 3. Krishna C. Solid-state fermentation systems-an overview. Crit Rev Biotechnol. 2005 Jan-Jun;25(1-2):1-30. doi: 10.1080/07388550590925383. PMID: 15999850. 4. Ge, X., Vasco-Correa, J., & Li, Y. (2017). Solid-State Fermentation Bioreactors and Fundamentals. Current Developments in Biotechnology and Bioengineering, 381–402. doi:10.1016/b978-0-444-63663-8.00013-6 5. Rodriguez-Leon, J.A., Soccol, C.R., Pandey, A., Rodriguez, D.E. (2008). Factors Affecting Solid-state Fermentation. In: Pandey, A., Soccol, C.R., Larroche, C. (eds) Current Developments in Solid-state Fermentation. Springer, New York, NY. (https://doi.org/10.1007/978-0-387-75213-6_3) 6. Hongzhang Chen (2013) Modern Solid State Fermentation: Theory and Practice, Springer

MB 625 MJP: Practicals Based on Advances in Microbial Technology
Group III Major Elective Practical Paper
Total: 2 Credits | Workload: 30 hrs/credit
(Total Workload: 2 credits × 30 hrs = 60 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Understand practical aspects of immobilization of cells and enzymes
CO 2	Gain knowledge about factors affecting immobilization
CO 3	Carry out laboratory-scale production of exopolysaccharides/bioemulsifiers
CO 4	Understand optimization techniques in microbial fermentation
CO 5	Learn practical aspects of the kinetics of microbial growth
CO 6	Produce enzymes using solid-state fermentation

MB 625 MJP: Practicals Based on Advances in Microbial Technology
Group III Major Elective Practical Paper
Total: 2 Credits | Workload: 30 hrs/credit
(Total Workload: 2 credits × 30 hrs = 60 hrs in semester)

Sr. No.	Practical Title	No. of Hours
1	Bioconversions using immobilized systems (whole cells/enzyme)	
2	Testing the effect of gel concentration on bioconversion using immobilization	
3	Testing the effect of cell/enzyme concentration on bioconversion using immobilization	
4	Laboratory scale production and media optimization for exopolysaccharide/bio-emulsifier production	
5	Batch growth kinetics and establishment of key kinetic parameters: a. Maximum specific growth rate (μm) b. Saturation constant, (Ks) c. Overall yield of biomass (Yx/s) g cell d. Overall productivity of biomass, g cell	
6	Solid state fermentation: a. Isolation of the fungus capable of producing specific enzyme b. Production of any enzyme by SSF using a suitable substrate c. Establishment of the time course of enzyme production d. Effect of inoculum size and type of substrate on enzyme production	

Suggested References for MB 625 MJP: Practicals Based on Advances in Microbial Technology
Group III Major Elective Practical Paper

1. Arana-Peña S., Rios N. S., Carballares D., Mendez-Sanchez C., Lokha Y., Gonçalves L. and Fernandez- Lafuente R. (2020). Effects of enzyme loading and immobilization conditions on the catalytic features of lipase from Pseudomonas fluorescens immobilized on octyl -agarose beads. Frontiers in bioengineering and biotechnology. 8: 36.
2. Brena B, González-Pombo P and Batista-Viera F. (2013). Immobilization of enzymes: a literature survey. Methods Mol Biol. 1051: 15-31.
3. Gedam P. S., Raut A. N. and Dhamole P. B. (2019). Effect of operating conditions and immobilization on butanol enhancement in an extractive fermentation using non-ionic surfactant. Appl Biochem Biotechnol. 187: 1424–1436

4. Mahajan R., Gupta V. K. and Sharma J. (2010). Comparison and suitability of gel matrix for entrapping higher content of enzymes for commercial applications. Indian J Pharm Sci. 72(2): 223-228
5. Biswas J. and PaulA. K. (2017). Optimization of factors influencing exopolysaccharide production by Halomonas xianhensis SUR308 under batch culture. AIMS Microbiology, 3(3): 564–579.
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8. Monod J. The growth of bacterial cultures. Annu Rev Microbiol. 1949;3:371–394.
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11. Sahnoun, M., Kriaa, M., Elgharbi, F., Ayadi, D.-Z., Bejar, S., & Kammoun, R. (2015). Aspergillus oryzae S2 alpha-amylase production under solid state fermentation: Optimization of culture conditions. International Journal of Biological Macromolecules, 75, 73-80. doi: https://doi.org/10.1016/j.ijbiomac.2015.01.026
12. Panday A. (2009). Solid state fermentation, New Age International publishers

MB 626 MJ: Industrial Wastewater Treatment and Industrial Production of Vaccines
Group III Major Elective Theory Paper
Total: 2 Credits | Workload: 15 hrs/credit
(Total Workload: 2 credits × 15 hrs = 30 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Understand parameters affecting the treatment of industrial wastewater
CO 2	Get in-depth knowledge about activated sludge treatment and its analysis
CO 3	Gain knowledge of advanced wastewater treatment methods
CO 4	Understand the various types of vaccines and their applications
CO 5	Gain detailed knowledge related to vaccines and their clinical trials
CO 6	Learn the aspects of various generations of vaccines

MB 626 MJ: Industrial Wastewater Treatment and Industrial Production of Vaccines
Group III Major Elective Theory Paper
Total: 2 Credits | Workload: 15 hrs/credit
(Total Workload: 2 credits × 15 hrs = 30 hrs in semester)

Credit	Credit Title and Contents	No. of Hours
I	**Industrial Wastewater Treatment** A. Introduction to Wastewater B. Biological Wastewater Treatment: 1. Aerobic and anaerobic treatment 2. Suspended and attached growth processes C. Activated Sludge Treatment and Analysis 1. Reactions and kinetics 2. Mass balance analysis 3. Hydraulic characters 4. Critical operating parameters like DO, hydraulic retention time, mean cell retention time, F/M ratio D. Advanced Nanofiltration Method for Wastewater Treatment E. Current Industrial Wastewater Treatment Processes (wastewater composition, physico-chemical properties and effluents treatment methods with reference to): 1. Dairy industry 2. Food processing industry 3. Dyeing industry/dye-house effluents 4. Paper and pulp industry: effluent disposal and reuse	15
II	**Industrial Production of Vaccines** A. Introduction to Vaccines B. Types of Vaccines: inactivated, attenuated, toxoid, subunit, conjugate, experimental, valence, heterotypic C. Production and Purification of the vaccines 1. Pilot and industrial-scale production 2. Excipients 3. Role of adjuvants and preservatives 4. Purification of vaccines D. Production of viral, bacterial and protozoal vaccines 1. Generations of vaccines 2. Subunit vaccines (Hepatitis B)	15

	3. Recombinant vaccines (Rotavirus) 4. Hapten-conjugate vaccines (diphtheria) 5. Third-generation vaccines – DNA/RNA and idiotype vaccines (malaria) 6. Next-generation vaccines using OMICs approach (SARS) 7. COVID vaccines E. Clinical Trials of Vaccines	

Suggested References for MB 626 MJ: Industrial Wastewater Treatment and Industrial Production of Vaccines
Group III Major Elective Theory Paper

Credit	References
I	**Industrial Wastewater Treatment** 1. Abdallh M. N., Abdelhalim W. S. and Abdelhalim H. S. (2016). Industrial wastewater treatment of food industry using best techniques. International Journal of Engineering Science Invention, 5(8): 15-28. 2. Ali Z. and Rahman M. (2008) Physico-chemical characteristics of pulp and paper mill effluent. Research in Environment and Life Sciences.1 (2): 59-60. 3. Ashtekar S., Bhandari V. M., Shirsath S. R., Sai Chandra P. L. V. N. and Jolhe P. D. (2013). Dye wastewater treatment: removal of reactive dyes using inorganic and organic coagulants. Journal of Industrial Pollution Control, 30(1): 33-42 4. Bajpai P. and Bajpai P. K. (1994). Mini review: Biological colour removal of pulp and paper mill wastewaters. Journal of Biotechnology. 33: 211-220. 5. Bajpai P. (2001). Microbial degradation of pollutants in pulp mill effluents. Advances in Applied Microbiology.48: 79-134. 6. Catalkaya E.C. and Kargi F. (2006). Color, TOC and AOX removals from pulp mill effluent by advanced oxidation processes: A Comparative Study. Journal of Hazardous Materials. 139 (2): 244-253 7. Metcalf and Eddy (Eds.). (1991). 3rd Edition, Tata Mac Graw Hill Publishing Co. Ltd. New Delhi. 8. Patwardhan A. D. (2008). Industrial wastewater treatment. © Prentice – Hall of India Pvt. Ltd., New Delhi. ISBN 978-81-203-335 9. Tchobanoglous G. and Burton F. L. (1991) Wastewater engineering, treatment, disposal and reuse. 3rd Edition, Metcalf and Eddy (Eds.), Tata Mac Graw Hill Publishing Co. Ltd. New Delhi 10. Emerging technologies for waste water treatment and in-plant wet weather management. 2013. EPA United States Environmental Protection Agency. Virginia 11. Arup Roy A and J Bhattacharya. Nanotechnology in industrial waste water treatment. 2015. IWA Publishing Alliance, London. 12. Global good practices in industrial waste water treatment and disposal/reuse, with special reference to common effluent treatment plants. 13. Gadipelly C, Perez-Gonza´ lez A, Yadav G, Ortiz I, Ibańez R, Rathod V, and Marathe K. 2014. Pharmaceutical industry waste water: Review of the technologies for water treatment and reuse. Ind. Eng. Chem. Res. 53:11571−1159
II	**Industrial Production of Vaccines** 1. Vaccines: A clinical overview and practical guide. (2021). Editors: Joseph Domachowske, Manika Suryadevara. ISBN: 978-3-030-58416-0. Publisher: Springer. DOI: https://doi.org/10.1007/978-3-030-58414-6 2. Wen E. P., Ellis R. and Pujar N. (2014). Vaccine Development and Manufacturing. ISBN:9780470261941. DOI:10.1002/9781118870914 3. Orenstein W. A., Offit P. A., Edwards K. M. and Plotkin S. A. (2022) Plotkin's Vaccines. 8th Edition. ISBN: 9780323790581. Publisher: Elsevier

	4. Casida L. E. (1984). Industrial Microbiology.Wiley Easterbs, New Delhi 5. Patel A. H. (1985). Industrial Microbiology, Macmillan India Ltd. 6. Soma Marla S., Bonthala V. S., München H. Z., Suresh., Gaur V. S. and Gohar Taj G. (2012). Biotechnology in Medicine and Agriculture Principles and Practices. Publisher: I.K International Publishing House pvt.ltd, Editors: Anil Kumar, Ashwani Pareek, and Sanjay Mohan Gupta. 739-759 https://www.bio.fiocruz.br/en/images/stories/pdfs/mpti/2013/selecao/vaccine-process-technology.pdf 7. https://www.dcvmn.org/IMG/pdf/ge_healthcare_dcvmn_introduction_to_pd_for_vaccine_production_29256323aa_10mar2017.pdf 8. https://www.sciencedirect.com/science/article/pii/B9780128021743000059 9. https://www.researchgate.net/publication/313470959_Vaccine_Scale-up_and_Manufacturing

MB 626 MJP: Practicals Based on Industrial Wastewater Treatment and Industrial Production of Vaccines
Group III Major Elective Practical Paper
Total: 2 Credits | Workload: 30 hrs/credit
(Total Workload: 2 credits × 30 hrs = 60 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Estimate different physico-chemical parameters of wastewater
CO 2	Estimate solids from industrial wastewater
CO 3	Prepare and perform lab-scale degradation of synthetic wastewater
CO 4	Test vaccine potency by immunodiffusion assay
CO 5	Prepare bacterial somatic and flagellar antigens
CO 6	Estimate bacterial antigens using antibodies

MB 626 MJP: Practicals Based on Industrial Wastewater Treatment and Industrial Production of Vaccines
Group III Major Elective Practical Paper
Total: 2 Credits | Workload: 30 hrs/credit
(Total Workload: 2 credits × 30 hrs = 60 hrs in semester)

Sr. No.	Practical Title	No. of Hours
1	Estimation of different solids (TS, TSS and TDS) from food/dairy/pharmaceutical industry wastewater (effluent) (any two different wastewater samples)	
2	Setting up a laboratory experiment to assess the degradability of synthetic wastewater	
3	Checking the potency of a toxoid-based vaccine by immune diffusion assay	
4	Preparation of *Salmonella* O and H antigens	
5	Estimation of *Salmonella* O and H antigens with known antibodies	

Suggested References for MB 626 MJP: Practicals Based on Industrial Wastewater Treatment and Industrial Production of Vaccines
Group III Major Elective Practical Paper

1. Barthwal R. R. (2002). Environmental Impact Assessment, New Delhi (India). New Age International (P) Limited Publishers.
2. Eaton A. D. (2005). Standard methods for the examination of water and wastewater. American Public Health Association. American Water Works Association. Water Environment Federation. Publisher: APHA-AWWA-WEF, Washington, D.C. 21st edition
3. Glasson J., Therivel R. and Chadwick A. (2012). Rutledge-Taylor and Francis Introduction to Environmental Impact Assessment. 4th Edition. 416 pages
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5. Cruickshank R. (1982). Medical Microbiology, 12th Edition, P.403. 2. Felix A. (1942) Brit. Med. J. 11: 597.
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7. Vaerman J. P. (1981). Single radial immune diffusion, in methods in enzymology. 73 (Langone, J. J. And Van Vunakis, H, Eds.) New York. 291-305

MB 627 MJ: Biosafety, Bioethics and Intellectual Property Rights
Group III Major Elective Theory Paper
Total: 2 Credits | Workload: 15 hrs/credit
(Total Workload: 2 credits × 15 hrs = 30 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Understand the safety and risks associated with laboratory experiments (especially microbiology experiments) and biological inventions
CO 2	Gain knowledge about the guidelines and regulatory bodies concerning biosafety
CO 3	Understand ethics and guidelines to protect biological inventions
CO 4	Analyse and apply bioethical principles in biomedical settings and research
CO 5	Comprehend various Intellectual Property Rights and the regulatory affairs linked with biosafety and bioethics
CO 6	Apply concepts of Intellectual Property Rights to protect their innovative ideas

MB 627 MJ: Biosafety, Bioethics and Intellectual Property Rights
Group III Major Elective Theory Paper
Total: 2 Credits | Workload: 15 hrs/credit
(Total Workload: 2 credits × 15 hrs = 30 hrs in semester)

Credit	Credit Title and Contents	No. of Hours
I	**Biosafety** A. Concepts in Biosafety and Primary Containment for Biohazards 1. Biological safety cabinets, shipment of biological specimens, biological waste management, decontamination, medical surveillance, emergency response 2. Principles of Good Laboratory Practices and general laboratory requirements for biosafety B. Biosafety Guidelines and Recommended Biosafety Levels 1. Biosafety conventions and guidelines: Cartagena protocol, OECD guidelines, Rules (1989) for GMOs 2. Biosafety levels for biocontainment (Biosafety levels: 1, 2, 3, 4) 3. GRAS organisms and risk or hazard groups of infectious agents 4. Risk analysis, risk assessment, risk management and risk communication C. Regulatory Framework for Biosafety in India (roles and functions of Indian regulatory bodies): 1. Institutional Biosafety Committee (IBSC) 2. Review Committee on Genetic Modification (RCGM) 3. Genetic Engineering Appraisal Committee (GEAC) 4. Food Safety and Standards Authority of India (FSSAI) 5. Central Drug Standards Control Organisation (CDSCO) 6. Central Pollution Control Board (CPCB)	15
II	**Bioethics and Intellectual Property Rights** A. Bioethics 1. Introduction, history and ethical principles 2. Importance, ethical guidelines, policy, regulations and supplementary guidance related to biomedical research 3. Genetic engineering ethics: genetic privacy, patenting of genes, gene therapy	15

	4. Bioethics in healthcare: patient confidentiality, informed consent, euthanasia, prenatal diagnosis, genetic screening, transplantation, trading of human life 5. Bioethics in research: genetic engineering, cloning and stem cell research, human and animal experimentation, eugenics, animal rights/welfare, bioterrorism B. Intellectual Property Rights (IPRs) 1. Introduction and types of IPRs 2. Patents: introduction, patent registration process overview, patent types in India - utility (inventions), design and plants 3. Overview of copyrights, trademarks, industrial designs, trade secrets, geographical indications farmer's rights and plant variety protection, traditional knowledge 4. IPR for biological sciences: patenting of transgenic organisms, isolated genes and microorganisms 5. International conventions and cooperation: Paris Convention (1883), WIPO Convention (1967), Patent Cooperation Treaty (1970), GATT and TRIPS Agreement 6. Current status of IPR in India	

Suggested References for MB 627 MJ: Biosafety, Bioethics and Intellectual Property Rights Group III Major Elective Theory Paper	
Credit	**References**
I	**Biosafety** 1. Parashar S. and Goel D. (2013). IPR, Biosafety and Bioethics. Pearson India Publishers 7. Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India (http://www.envfor.nic.in/ divisions/csurv/geac/annex-5.pdf) 8. Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J.W., Burachik, M., Gray, A., Wu, F. (2009). Problem Formulation in the Environmental Risk Assessment for Genetically Modified Plants. Transgenic Research, 19(3),425-436. doi:10.1007/s11248-009-9321-9 9. Craig, W., Tepfer, M., Degrassi, G., and Ripandelli, D. (2008). An Overview of General Features of Risk Assessments of Genetically Modified Crops. Euphytica, 164(3), 853-880. doi:10.1007/s10681-007-9643-8 10. Thomas J.A. and Fuch R. L. (2002). Biotechnology and safety Assessment (3rd Ed) Academic Press. 11. Notification from Department of Biotechnology, Ministry of Science and Technology, India. (2020) Revised simplified procedures/guidelines on Import, Export and Exchange of GE organisms and product thereof for R& D purpose. File no. BT/BS/17/635/2015-PID. dated-17/01/2020 12. Indian Biosafety Knowledge Portal website: https://ibkp.dbtindia.gov.in/ 13. Central Drug Standards Control Organisation website: https://cdsco.gov.in/opencms/opencms/en/About-us/Functions/ 14. Central Pollution Control Board website: https://cpcb.nic.in/functions/
II	**Bioethics and Intellectual Property Rights** 1. Kuhse, H. (2010). Bioethics: An Anthology. Malden, MA: Blackwell Publishing 2. Encyclopedia of Bioethics 5 vol set, (2003) ISBN- 10: 0028657748 4. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. (http://www.ipindia.nic.in/)

	5. Mathur R. (Au. and Ed.). (2017). National Ethical Guidelines For Biomedical and Health Research Involving Human Participants. Publisher Indian Council of Medical Research. ISBN:978-81-910091-94 6. Borem A., Bowen D. E. and F. R. Santos F. R. (2003). Understanding Biotechnology. 1st edition, Pearson Education Inc. 7. Barnum S. R. (2004). Biotechnology an Introduction. Brooks/Cole; International Edition 8. Joshi R. (2006). Biosafety and Bioethics. Isha Books, Delhi, 2006. 9. Bryant J. A. and la Velle Bryant L. B. (2005). Introduction to Bioethics. 1st edition, Wiley Blackwell Publishing 10. World Trade Organisation website: http://www.wto.org 11. World Intellectual Property Organisation website: http://www.wipo.int 12. International Union for the Protection of New Varieties of Plants: http://www.upov.int 13. National Portal of India website: http://www.archive.india.gov.in 14. National Biodiversity Authority website: http://www.nbaindia.org 15. Raju C. B. (2007). Intellectual Property Rights. 1st edition, Serials Publications 16. Wadehra B. L. (2007). Law Relating to Intellectual Property. Universal Law Publishing CO., Fourth Edition 17. Greif K. F. and Merz J. F. (2001). Current Controversies in the Biological Sciences - Case Studies of Policy Challenges from New Technologies, MIT Press 18, Biotechnology: A comprehensive treatise (Vol. 12). Legal economic and ethical dimensions VCH. (2nded) ISBN- 10 3527304320. 2

MB 627 MJP: Practicals Based on Biosafety, Bioethics and Intellectual Property Rights
Group III Major Elective Practical Paper
Total: 2 Credits | Workload: 30 hrs/credit
(Total Workload: 2 credits × 30 hrs = 60 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Understand the importance of biosafety and its guidelines thoroughly
CO 2	Gain knowledge of biological waste disposal in biomedical settings
CO 3	Know the various Indian regulatory bodies concerning biosafety and their functions
CO 4	Understand the importance of the principles concerning bioethical issues
CO 5	Learn the process and documentation practically involved in bioethical issues
CO 6	Learn the process and documentation practically involved in IPR

MB 627 MJP: Practicals Based on Biosafety, Bioethics and Intellectual Property Rights
Group III Major Elective Practical Paper
Total: 2 Credits | Workload: 30 hrs/credit
(Total Workload: 2 credits × 30 hrs = 60 hrs in semester)

Sr. No.	Practical Title	No. of Hours
1	FSSAI regulations test methods for drinking water: detection of sulphite-reducing anaerobes (clostridia) (at least two different samples)	5
2	FSSAI regulations test methods for water/butter/cheese/milk products for the processed food industry: proteolytic plate count or lipolytic plate count (at least two different samples)	5
3	FSSAI regulations microbiological testing of food: detection and confirmation of *Listeria monocytogenes* in foods (at least two different samples)	10
4	A case study on handling and disposal of biomedical waste from a hospital, a blood bank or any other suitable biomedical setting	10
5	A case study on ethical issues related to clinical trials of drugs in India or abroad	10
6	Proxy filing or thorough referencing of Indian Product patent	5
7	Proxy filing or thorough referencing of Indian Process patent	5
8	Visit to a hospital/blood bank/any other biomedical Organisation to understand biosafety protocols followed	10

Suggested References for MB 627 MJP: Practicals Based on Biosafety, Bioethics and Intellectual Property Rights
Group III Major Elective Practical Paper

1. Manual of Methods for Analysis of Water 2017. Food Safety and Standards Authority of India (FSSAI), Ministry Of Health and Family Welfare Government of India, New Delhi. (https://fssai.gov.in/upload/uploadfiles/files/Manual_Water_Analysis_09_01_2017(1).pdf)
2. Manual of Methods of Analysis of Dairy and Dairy Products- 2nd edition. 2023. Food Safety and Standards Authority of India (FSSAI), Ministry Of Health and Family Welfare Government of India, New Delhi. (https://fssai.gov.in/upload/uploadfiles/files/Manual_Dairy_07_10_2022.pdf)
3. Draft Manual on Method of Microbiological Testing (2016) Microbiology of Foods. Food Safety and Food Standards. (https://old.fssai.gov.in/Portals/0/Pdf/Microbiological_Testing_Foods_Draft_Manual_06_09_2016.pdf) (https://archive.fssai.gov.in/home/food-testing/food-testing-manual.html)
4. Manual for Good Food Laboratory Practices (GFLPs). (2018). Food Safety and Standards Authority of India (FSSAI), Ministry Of Health and Family Welfare Government of India, New Delhi

5. Jain V., Sharma V. K., Kumar A. and Jain S. (2011). Biomedical Waste Management – A Case Study of Bhopal City. Nat. Env. Poll. Tech. 10(2):281-284. (https://www.nswai.org/e_library.php)
6. Radha K. V., Kalaivani K. and Lavanya R. (2009). A Case Study of Biomedical Waste Management in Hospitals. Global J. Health Sci. 1(1):82-88
7. National Solid Waste Association of India (NSWAI) Manuals: https://www.nswai.org/e_library.php
8. Babu B. R., Parande R. Rajalakshmi P. and Volga S. M. (2009). Management of Biomedical Waste in India and Other Countries: A Review. J Int. Env. Appl. Sci. 4 (1): 65-78
9. Nardini C. (2014) The ethics of clinical trials. Ecancermedicalscience. 8: 387. doi: 10.3332/ecancer.2014.387
10. de Silva R. E. Amato A. A., Guilhem D. B. de Carvalho M. R., Lima E. da C. and Novaes M. R. C. G. (2018). Factors Contributing to Exacerbating Vulnerabilities in Global Clinical Trials. Front. Pharmacol. doi: 10.3389/fphar.2017.00999
11. WHO Guidelines: Ensuring ethical standards and procedures for research with human beings: https://www.who.int/activities/ensuring-ethical-standards-and-procedures-for-research-with-human-beings
12. US-FDA Guidelines: Clinical Trials and Human Subject Protection: https://www.fda.gov/science-research/science-and-research-special-topics/clinical-trials-and-human-subject-protection
13. Indian Patent Office: E-filing of Patent Applications: https://ipronline.ipindia.gov.in/epatentfiling/goForLogin/doLogin
14. Indian Patent Office Resources: Acts, Rules, Manuals and Guidelines: https://www.ipindia.gov.in/resources.htm#Guidelines

MB 620 RP: Major Research Project
Dissertation
Total: 6 Credits | Workload: 30 hrs/credit
(Total Workload: 6 credits × 30 hrs = 180 hrs in semester)

Course Outcomes (COs)	
After studying the course learners will be able to:	
CO 1	Investigate a scientific question scientifically
CO 2	Measure various parameters by performing experiments
CO 3	Organise the obtained data in an appropriate tabulated or graphical form
CO 4	Analyze and interpret the data generated from experiments
CO 5	Discuss and communicate their scientific results in a written form as a dissertation thesis
CO 6	Present and explain their research findings to the audience effectively

MB 620 RP: Major Research Project
Dissertation
Total: 4 Credits | Workload: 30 hrs/credit
(Total Workload: 4 credits × 30 hrs = 120 hrs in semester)

Course Objectives:

1. To prepare the students to adapt to the research environment
2. To understand how projects are executed in a research laboratory
3. To learn practical aspects of research
4. To train students in the art of data analysis and thesis writing

Expected Skill Development/Improvement:

Students will learn: (a) how to select and defend a topic of their research; (b) how to effectively plan, execute, evaluate and discuss their experiments

Students will develop/improve the following skills:

1. In-depth knowledge of the chosen area of research
2. Capability to critically and systematically integrate knowledge to identify issues that must be addressed within the framework of a specific thesis
3. Competence in research design and planning
4. Capability to create, analyse and critically evaluate different technical solutions
5. Ability to conduct research independently
6. Ability to perform analytical techniques/experimental methods
7. Project management skills
8. Report writing skills
9. Problem solving skills
10. Communication and interpersonal skills

Course Content:

1. Planning and Performing Experiments:
   Based on the project proposal submitted in the earlier semester, students will plan, and engage in, an independent and sustained critical investigation and evaluate the chosen research topic relevant to biological sciences and society. Students will systematically identify relevant theories and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. Supervisors will train the students such that they can work independently and are able to understand the aim of each experiment performed by them. Students should be able to understand the possible outcomes of each experiment.
2. Dissertation Thesis Writing:
   At the end of their dissertation project, a thesis will be written by the student giving all the details of the dissertation project, such as aim, methodology, results, discussion and future aspects related to their project. Students may aim to get their research findings published in a peer-reviewed

journal. If the research findings have application-oriented outcomes, the students may file a patent application.

3. Dissertation Thesis Submission and *Viva-voce*:
   Students will submit a printed and hardbound copy of their dissertation thesis for internal assessment. Students will also prepare a PowerPoint presentation of their dissertation thesis for oral presentation during the *Viva-voce*, as part of external evaluation. During the *Viva-voce*, the students will explain their methodologies, results and discussion, along with future aspects in detail.