Savitribai Phule Pune University

(Formerly University of Pune)

Faculty of Science and Technology

Revised Syllabi for

M.Sc. (Microbiology) Part-II NEP 2020

For Colleges Affiliated to
Savitribai Phule Pune University

To be implemented from Academic Year 2024-2025

Title of the Program: M.Sc. (Microbiology) NEP 2020

1. Preamble:

The main theme of teaching the microbiology program is the application of basic principles of life sciences to develop into technology. Modern biology combines the principles of chemistry and biological sciences (molecular and cellular biology, genetics, and immunology) with technological disciplines (engineering, computer science) to produce goods and services and for environmental management. Tools of molecular biology play an important role in the preparation of an engineered clone, a recombinant or a genetically manipulated organism (GMO). The objective of the Master's Programme in Microbiology is to equip the students with updated knowledge of prokaryotic and eukaryotic cellular processes, microbial taxonomy, biostatistics, molecular biophysics, molecular biology and biochemistry.

The National Education Policy (NEP-2020), which is being implemented by the Ministry of Higher Education, the Government of India, and the University Grants Commission (UGC), offers opportunities for developing 21st-century advanced skills through research internships with faculty and researchers at their own or other HEIs/research institutes. Additionally, it acknowledges, pinpoints, and nurtures each student's distinct talents to support their overall growth and strengthen the country. This will empower Indian youngsters in the field of plant sciences globally and assist the country in establishing a solid foundation on the global market. Thus, the Board of Studies in Microbiology has identified the following thrust areas and prospective plans for syllabi reforms at the postgraduate level:

- **Microbial diversity:** Facets of microbial diversity which include morphological, structural, metabolic, ecological, behavioral and evolutionary aspects
- **Microbial diversity in extreme environments:** Properties and application of extremophiles and also includes collecting information of diversity, exploration and utilization of diversity to identify and harvest biomolecules for human health improvisation, microorganisms from extreme environments, Archaebacteria, etc.
- **Mathematical approach for biologists:** Numerical Microbiology Problem solving, Concept of mathematical models, Application of Mathematical models to microbiological processes
- **Advanced biochemistry and molecular biology techniques:** Chromatography techniques, next-generation sequencing methods (Pyrosequencing, Ion torrent, Nanopore sequencing)
- **Morphogenesis and organogenesis in plants**
- **Research methodology:** Use of search engines for scientific data mining, use of reference management tools, statistical data analysis using software

To enrich students' knowledge and train them in the above-mentioned areas; we feel certain topics in the present syllabus need to be supplemented and strengthened by including a few additional topics. Areas that need to be introduced in syllabi have been identified as:

- Extremophiles
- Bioinformatics
- Mathematical approach for biologists

- Molecular tools for the characterization and identification of bacteria
- Advanced biochemistry techniques
- Advanced molecular biology techniques
- Advances in microbial technology
- Morphogenesis and organogenesis in plants
- Signal transduction
- Radioisotopes in biology and confocal microscopy
- Biosafety, bioethics and intellectual property rights

In addition, we feel that the students should be well acquainted with research methodology which includes different skill developments in scientific writing, data handling and processing, development of research ideas and planning/designing of research projects. The skill sets thus evolved will help the students in academic and applied research. This syllabus aims to give the student a significant level of theoretical and practical understanding of the subject.

2. Introduction:

With the changing scenario at the local and global levels, we feel that the syllabus orientation should be altered to keep pace with developments in the education sector. The need of the hour is proper syllabi that emphasize on teaching of technology as well as the administrative aspects of modern biology. Theory supplemented with extensive laboratory expertise will help these students to avail these opportunities. Both these aspects, i.e. theory and more practicals need to be stressed, such that a postgraduate student can start work directly in applied fields (industry or institutions), without any additional training.

Thus, the university/college itself will be developing trained and skilled manpower. We are restructuring the syllabus from this viewpoint. The restructured syllabus will combine the principles of chemistry and biological sciences (molecular and cell biology, genetics, immunology and analytical tools, biochemistry, biostatistics and bioinformatics) with technological disciplines to produce goods and services and for environmental management.
Microbiology curricula are operated at two levels viz. undergraduate and postgraduate. The undergraduate curricula are prepared to impart basic knowledge of the respective subject from all possible angles. In addition, students are to be trained to apply this knowledge, particularly in day-to-day applications of Microbiology and to get a glimpse of research.

3. Objectives to be Achieved:

- To enrich students' knowledge and train them in the pure microbial sciences
- To introduce the concepts of mathematics in biology
- To inculcate research aptitude
- To inculcate sense of scientific responsibilities and social and environment awareness
- To help students build-up a progressive and successful career in Microbiology

4. Course Structure and Assessment of Credits:

I. Total Credits:

A full master's degree course in Sciences would be of 88 credits. Each theory credit course will be one clock hour per week, running for 15 weeks and each practical credit course will consist of 30 clock hours of laboratory exercises. There shall be four semesters and credits are distributed over 4 semesters. There will be 2 major core theory courses (4 credits each), one major core theory course (2 credits) and one major core practical course (4 credits). In addition, elective courses will be offered, each consisting of a 2-credit theory course and an allied 2-credit practical course. There are also Research Methodology (RM), Internship/On Job Training (OJT) and Research Project credits assigned to a particular semester.

Savitribai Phule Pune University, Pune

Credit Framework for Post Graduate (PG)

Level	Semester	Credits Related to Major		Research Methodology (RM)	Internship/ On Job Training (OJT)	Research Project (RP)	Total
		Major Core	Major Elective				
6.0	I	10 (T) + 4 (P)	2 (T) + 2 (T/P)	4	0	0	**22**
	II	10 (T) + 4 (P)	2 (T) + 2 (T/P)	0	4 (O/T)	0	**22**
Exit option: Award PG Diploma on completion of 44 credits after three years UG Degree **OR** continue with PG second year							
6.5	III	10 (T) + 4 (P)	2 (T) + 2 (T/P)	0	0	4	**22**
	IV	8 (T) + 4 (P)	2 (T) + 2 (T/P)	0	0	6	**22**
Total 4 Years		**54**	**16**	**4**	**4**	**10**	**88**
2 years - 4 Sem. Award PG Degree on completion of 88 credits after Three Year UG Degree or 1 Year - 2 Sem PG Degree (44 credits) after Four Year UG degree							

II. M.Sc. Second-year Microbiology Semester III Assessment of Credits:

MB: Microbiology; MJ: Major; MJP: Major Practical; RP: Research Project

Components of Study	Course Code		Course Name	Credits	Assessment		
					IA	UE	Total
Major Core Theory Papers	MB 601 MJ		Immunology	4	30	70	100
	MB 602 MJ		Molecular Biology II	4	30	70	100
	MB 603 MJ		Clinical Microbiology	2	15	35	50
Major Core Practical Paper	MB 604 MJP		Practicals based on MB 601 MJ Immunology, MB 602 MJ Molecular Biology II, and MB 603 MJ Clinical Microbiology	4	30	70	100
Research Project	MB 631 RP		Research Project	4	30	70	100
Major Elective (Theory + Practical) Papers (Choose any one group)	Group I	MB 610 MJ	Cell Culture Techniques	2	15	35	50
		MB 610 MJP	Practicals Based on MB 610 MJ Cell Culture Techniques	2	15	35	50
	Group II	MB 611 MJ	Bioremediation and Biomass Utilization	2	15	35	50
		MB 611 MJP	Practicals Based on MB 611 MJ Bioremediation and Biomass Utilization	2	15	35	50
	Group III	MB 612 MJ	Microbial Virus Technology	2	15	35	50
		MB 612 MJP	Practicals based on MB 612 MJ Microbial Virus Technology	2	15	35	50
	Group IV	MB 613 MJ	Clinical Microbiology and Parasitology	2	15	35	50
		MB 613 MJP	Practicals based on MB 613 MJ Clinical Microbiology and Parasitology	2	15	35	50

III. M.Sc. Second-year Microbiology Semester IV Assessment of Credits:

MB: Microbiology; MJ: Major; MJP: Major Practical; RP: Research Project

Components of Study	Course Code		Course Name	Credits	Assessment		
					IA	UE	Total
Major Core Theory Papers	MB 651 MJ		Pharmaceutical Microbiology	4	30	70	100
	MB 652 MJ		Bioprocess Technology	4	30	70	100
Major Core Practical Paper	MB 653 MJP		Practicals based on MB 651 MJ Pharmaceutical Microbiology and MB 652 MJ Bioprocess Technology	4	30	70	100
Research Project	MB 681 RP		Major Research Project	6	45	105	10
Major Elective (Theory + Practical) Papers (Choose any one group)	Group I	MB 660 MJ	Quality Assurance and Validation in the Pharmaceutical Industry and Development of Anti-infectives from Plants	2	15	35	50
		MB 660 MJP	Practicals Based on MB 660 MJ Quality Assurance and Validation in the Pharmaceutical Industry and Development of Anti-infectives from Plants	2	15	35	50
	Group II	MB 661 MJ	Advances in Microbial Technology	2	15	35	50
		MB 661 MJP	Practicals Based on MB 661 MJ Advances in Microbial Technology	2	15	35	50
	Group III	MB 662 MJ	Industrial Wastewater Treatment and Industrial Production of Vaccines	2	15	35	50
		MB 662 MJP	Practicals based on MB 662 MJ Industrial Wastewater Treatment and Industrial Production of Vaccines	2	15	35	50
	Group IV	MB 663 MJ	Biosafety, Bioethics and Intellectual Property Rights	2	15	35	50
		MB 663 MJP	Practicals based on MB 663 MJ Biosafety, Bioethics and Intellectual Property Rights	2	15	35	50

IV. Course Evaluation:
Each course will be evaluated for 70% marks by UE and 30 % will be based on In-semester continuous assessment.

V. Examination Results:
Results at the end of the semester will be declared using a grade point system as per the University rules.

VI. The GPA:
The formula for GPA will be based on the weighted average. The final GPA will not be printed unless a student passes courses equivalent to a minimum of 88 credits. Total credit hour means a sum of credit hours of the courses which a student has passed.

VII. Rules and University Guidelines:
All other rules will be as per the university guidelines for postgraduate courses under the credit-based system.

VIII. Important Note:
The above circular supersedes all previous circulars on the credit system being operated at SPPU.

5. General Instructions:

The post-graduate degree will be awarded to students who obtain a total 88 credits (22 average credits per semester). One credit will be equivalent to 15 clock hours of teacher-student contact per semester.
The assessment shall consist of:
a) In-semester continuous assessment and
b) End-semester assessment.

The teacher concerned shall announce the units for which each in-semester assessment will take place. However, the end-semester assessment shall cover the entire syllabus prescribed for the course. An in-semester assessment of 30% marks should be continuous and at least two tests should be conducted for courses of 4 credits, and a teacher must select a variety of procedures for examinations such as:
1. Written test and/or midterm test (not more than one or two for each course)
2. Term paper
3. Journal/Lecture/Library notes
4. Seminar presentation and Short Quizzes
5. Assignments
6. Extension work
7. An open book test (with the respective subject teacher deciding what books are to be allowed for this purpose)
8. Mini research project by individual student or group of students

The concerned teacher in consultation with the Head of the PG Department shall

decide the nature of questions for the unit test. The semester-end examination for the remaining 70% marks will be conducted by Savitribai Phule Pune University. The student has to obtain 40% marks in the combined examination of In-semester assessment and Semester-End assessment with a minimum passing of 30% in both these separately. To pass the degree course, a student shall have to get a minimum aggregate 40% marks (E and above grade point scale) in each course. If a student misses an internal assessment examination, he/she will have a second chance with the permission of the Principal in consultation with the concerned teacher. Such a second chance shall not be the right of the student.

Internal marks will not change. A student cannot repeat internal assessment. Students who have failed the semester-end exam may reappear for the semester-end examination only twice in subsequent periods. The student will be finally declared as failed if he/she does not pass all credits within a total period of four years. After that, such students will have to seek fresh admission rules prevailing at that time. A student cannot register for the third semester, if she/he fails to complete 50% credits of the total credits expected to be ordinarily completed within two semesters.

There shall be the Re-evaluation of answer scripts of the semester examination but not of internal assessment papers as per Ordinance no. 134 A and B. While marks will be given for all examinations, they will be converted into grades. The semester-end grade sheets will have only grades and final grade sheets and transcripts shall have grade points average and total percentage of marks (up to two decimal points). The final grade sheet will also indicate the PG center to which the candidate belongs.

Each assessment/test will be evaluated in terms of grades. The grades for separate assignments and the final (semester-end) examination will be added together and then converted into a grade and later a grade point average. Results will be declared for each semester and the final examination will give total grades and grade point average.

6. Course conduct:

On Job Training (OJT): In this course, the students are expected to do the On-Job Training (OJT) or field project in appropriate industries, research institutes, NGOs, diagnostic labs etc. to get hands-on experience in the respective field. The department may conduct necessary lectures/workshops/seminars as a part of OJT. The course will be conducted as per the guidelines of the University and the Government of Maharashtra.

Research Project (RP): The course is to be completed under the supervision and guidance of an in-house research mentor. In case required, the mentor may collaborate with other institutes to permit the student to carry out part of the research project outside the department. Plan of work and literature review of project work to be carried out will be presented by the student in Semester III. Actual project will be carried out in Semester IV. The college may conduct necessary lectures/workshops/laboratory training exercises as a part of RP.

Reference: Savitribai Phule University‘s circular on ― Rules and Regulation for PG Choice Based credit system for Science Programme of Affiliated Colleges‖, effective from June 2019 and further amendments.

Program Specific Outcomes (PSOs) for M.Sc. Microbiology as per NEP-2020	
PSO No.	**Program Specific Outcomes (PSOs)** **Upon completion of this program the student will be able to**
PSO 1	**Academic Competence:** i) Describe microbial processes that can be used for the development of biochemical and immunological tools to improve the quality of human life. ii) Study the cytology, biochemistry, growth as well as application of environmentally and industrially important microbes with a specific emphasis on improving environmental sustainability and human health. iii) Describe and understand the concepts of role of microorganisms in geochemical processes like leaching of metals and bioremediation methods
PSO 2	**Personal and Professional Competence:** i) Apply tools of molecular taxonomy and bioinformatics to the study of diverse microbial groups. ii) Evaluate industrially important microbial products in terms of their purity, safety and ethically acceptable application for the benefit of mankind. iii) Combine public presentation skills of effective articulation and nonverbal communication with a sound understanding of microbial science to effectively communicate ideas
PSO 3	**Research competence:** i) Validate scientific hypothesis and editorialize experimental scientific data by using statistical tools applicable to biological sciences. ii) Integrate principles of biology and physical sciences to standardize detection and quantification methods using sophisticated techniques.
PSO 4	**Entrepreneurial and Social Competence:** i) Employ skill sets related to Quality assurance and testing of pharmaceutically important products in accordance with internationally accepted standards. ii) Evaluate the importance of new groups of consumer goods such as prebiotics, probiotics and nutraceuticals. iii) Apply the concepts of microbial interactions in basic and advanced treatment of waste water treatment processes.

MB 601 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 601 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 (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**	15

	A. Immunological tolerance 1. Central and peripheral immune tolerance 2. Mechanisms of tolerance induction (related experimentation using transgenic animals) 3. T cell-mediated suppression of immune response (T reg cells) B. Types of Immune Response Regulation 1. Regulation by antigen, antigen-antibody complexes 2. Niels Jerne's immune network theory and its experimental evidence 3. Cytokine-mediated cross-regulation of TH subsets (TH1-TH2) 4. Regulation of the complement system: classical and alternative pathways C. Biological Response Modifiers for Cancer Therapy	
III	**Experimental Immunology** A. *In Vitro* Systems: 1. Quantification of cytokines (Elispot assay) 2. Functional assays for phagocytes and cytokines (flow cytometry, cytotoxicity and growth assays) B. Cell Analysis Methods: 1. Tritiated thymidine (^{3}H-thymidine) uptake method 2. MTT assay 3. Assays of cell death (^{51}Cr release assay, comet assay) C. *In Vivo* Systems: 1. Ethical issues regarding the use of experimental animals 2. 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 1. Cellular transformations during neoplastic growth 2. Tumors of the lymphoid system (lymphoma, myeloma, Hodgkin's disease and non-Hodgkin's lymphoma) C. Tumor Antigens: 1. Tumor-specific antigens with examples 2. Tumor-associated antigens with examples D. Escape Mechanisms of Tumors From Host Defence: 1. Host immune response to tumor (effectors mechanisms) 2. Immuno surveillance theory 3. Immunoediting E. Diagnosis of Tumors: 1. Biochemical tumor markers 2. Immunological tumor markers F. Approaches in Cancer Immunotherapy: 1. Immune adjuvant and tumor vaccine therapy 2. CAR T cell therapy	15

Suggested References for MB 601 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 602 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 602 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	15

	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 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 602 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. 8. 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 9. Yashin A. I., Ukraintseva S. V., Akushevich I. V., Arbeev K. G., Kulminski A. and Akushevich L. (2009) Trade-off between cancer and aging: what role do other diseases play? Evidence from experimental and human population studies. Mech Ageing Dev. 130(1-2):98-104. 10. Kaeberlein M. (2013) Longevity and aging. F1000Prime Rep. 5:5
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)

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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/)

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MB 603 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 603 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 603 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 604 MJP: 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 604 MJP: 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 calculation of transformation efficiency	
6	Study of bacterial conjugation process 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 software	
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 604 MJP: Practicals Based on Immunology, Molecular Biology II and Clinical Microbiology
Major Core Practical Paper

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(https://www.ncbi.nlm.nih.gov/books/NBK21942/)
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Candida albicans directly from clinical specimens. Mycopathologia. 61(3): 151-157.
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19. Study of nucleic acid sequence database and sequence retrieval-NCBI: (https://www.ncbi.nlm.nih.gov/gene/)
20. 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 610 MJ: Cell Culture Techniques
Group I 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 610 MJ: Cell Culture Techniques
Group I 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 equipment 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** A. Cell Culture Types: 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 B. Cell Culture Techniques and Applications: 1. Techniques involved in animal cell culture 2. Cell culture systems and their applications	15

Suggested References for MB 610 MJ: Cell Culture Techniques Group I 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 610 MJP: Prcticals Based on Cell Culture Techniques
Group I 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 610 MJP: Practical Based on Cell Culture Techniques
Group I 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 610 MJP: Prcticals Based on Cell Culture Techniques
Group I 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 611 MJ: Bioremediation and Biomass Utilization
Group II 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 611 MJ: Bioremediation and Biomass Utilization
Group II 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 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 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	15

Suggested References for MB 611 MJ: Bioremediation and Biomass Utilization
Group II 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 611 MJP: Practicals Based on Bioremediation and Biomass Utilization
Group II 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 611 MJP: Practicals Based on Bioremediation and Biomass Utilization
Group II 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 611 MJP: Practicals Based on Bioremediation and Biomass Utilization
Group II 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.
4. Kumar Khanna V. (2007). Existing and emerging detection technologies for DNA (Deoxyribonucleic Acid) fingerprinting, sequencing, bio- and analytical chips: a multidisciplinary development unifying molecular biology, chemical, and electronics engineering. Biotechnol Adv. 25(1): 85-98.
5. Li J., Kim H. R., Lee H. M. and Yu H. C., Jeon E., Lee S. and Kim D. (2020). Rapid

biodegradation of polyphenylene sulfide plastic beads by *Pseudomonas* sp. Sci TotalEnviron. 720: 137616.

Qiu X., Wu P., Zhang H., Li M. and Yan Z. (2009). Isolation and characterization of *Arthrobacter* sp. HY2 capable of degrading a high concentration of p-nitrophenol. Bioresour Technol. 100(21): 5243-5248

7. Bano K. R., Kuddus M., Zaheer M. R., Zia Q., Khan M. F., Ashraf G. M., Gupta A. and Aliev G. (2017). Microbial enzymatic degradation of biodegradable plastics. Curr Pharm Biotechnol. 18(5): 429-440.

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11. McGinn P. J., Dickinson K. E., Bhatti S., Frigon J. C., Guiot S. R. and O'Leary S. J. (2011). Integration of microalgae cultivation with industrial waste remediation for biofuel and bioenergy production: opportunities and limitations. Photosynth Res. 109(1-3): 231-247.

12. Muhonja C. N., Makonde H., Magoma G. And Imbuga M. (2018). Biodegradability of polyethylene by bacteria and fungi from Dandora dumpsite Nairobi-Kenya. PLoS ONE13(7): e0198446.

13. Parmar A., Singh N. K., Pandey A., Gnansounou E. and Madamwar D. (2011). Cyanobacteria and microalgae: a positive prospect for biofuels. Bioresour Technol.102(22): 10163-10172.

14. Viramontes-Ramos S., Cristina Portillo-Ruiz M., Ballinas-Casarrubias Mde L, Torres-Muñoz J. V., Rivera-Chavira B. E. and Nevárez-Moorillón G. V. (2010). Selection of biosurfactant/bio-emulsifier-producing bacteria from hydrocarbon-contaminated soil. Braz J Microbiol. 41(3): 668-675.

MB 612 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 612 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** A. Bacteriophage-based Technology for the Decontamination of Water 1. Drinking water decontamination 2. Recreational water decontamination	15

	3. Medical wastewater decontamination B. Bacteriophage-based Technology for Medical Applications: 1. Pathogen control in aquatic systems 2. Biocontrol of biofilms on medical devices 3. Pathogen control in poultry 4. Bacteriophage and its products as therapeutic agents	

Suggested References for MB 612 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 3. Singh M.K., Maurya A. and Kumar S. (2020) Bioaugmentation for the treatment of waterborne pathogen contamination water. Waterborne Pathogens. 189–203. 4. Culot A., Grosset N. and Gautier M. (2019) Overcoming the challenges of phage therapy for industrial aquaculture: A review. Aquaculture. Elsevier. 513:734423. 5. Nakai T. and Park S. C. (2002) Bacteriophage therapy of infectious diseases in aquaculture. Mini-review. Research in Microbiology. 153: 13–18 6. Haradaa L. K., Silvaa E.C., Camposa W. F., Del Fiola F. S., Vilaa M., Dąbrowskab K., Krylovc V. N. and Balcão V. M. (2018) Applications of bacteriophages: State of the art, Review article. Microbiol Res. 212- 213:38-58 7. Lu T. K. and Collins J. J. (2007) Dispersing biofilms with engineered enzymatic bacteriophage. Proceedings of National Academy of Science. 104: 11197-11202 Kutter E. and Sulakvelidze A. Editors. (2005) Bacteriophage Therapy in Humans. Chapter 14. Bacteriophages, biology and applications. CRC Press. 8. Principi N., Silvestri E. and Esposito S. (2019) Advantages and Limitations of Bacteriophages for the Treatment of Bacterial Infections. Front. Pharmacol. 10: 513 Bacteriophages in Health and Disease 9. Hyman P. and Abedon S. T. Editors. (2012) Bacteriophages in Health and Disease. Volume 24 of Advances in molecular and cellular microbiology. Contributor C.A.B. International. Edition- illustrated. Publisher CABI. 10. Vázquez R., García E. and García P. (2018) Phage lysins for fighting bacterial respiratory infections: a new generation of antimicrobials. Mini review article. Front. Immunol. 9: 2252 11. Eric E. C. and Adhya S. L. (2015). Phage Therapy: Current Research and Applications. Clinical infectious diseases: an official publication of the Infectious Diseases Society of

	America. 61(1): 141–142 12. Gorski A., Miedzybrodzki R. and Borysowski J. (Editors). (2019) Phage Therapy: A Practical Approach. Springer International Publishing 13. 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 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 612 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 612 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 612 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

4. Ackerman H.W. (2009) Phage classification and characterization. In: Clokie MRJ, KropinskiAM (Eds) Bacteriophages: methods and protocols, Volume: Isolation, characterization and interactions, Vol. 501. Humana Press, New York,
5. Azeredo J. and Sillankorva S. Editors. (2018) Bacteriophage Therapy from Lab to Clinical Practice. In Methods in Molecular Biology. Walker J. M. Series Editor. Humana Press Book. Springer.
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
8. Balan A. and Padilla G. (1997) New thermal inducible phages isolated from tropical soils. Brazilian Journal of Genetics. 20: 4
9. 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
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
11. 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
12. 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

MB 613 MJ: Clinical Microbiology and Parasitology
Group IV 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 613 MJ: Clinical Microbiology and Parasitology
Group IV 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 Microbiolog6** 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	15

	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 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 613 MJ: Clinical Microbiology and Parasitology Group IV 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 613 MJP: Practicals Based on Clinical Microbiology and Parasitology
Group IV 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 613 MJP: Practicals Based on Clinical Microbiology and Parasitology
Group IV 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 613 MJP: Practicals Based on Clinical Microbiology and Parasitology
Group IV 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 631 RP: 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 631 RP: 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, individually or in groups (with a maximum of three students per group), will first select a lab/institute wherein they would like to pursue their dissertation project. Students individually or in groups (with a maximum of three students per group) will be asked to choose relevant research topics in consultation with their respective dissertation supervisor (departmental and/or external if planning to carry out their dissertation project 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 will 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 651 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 651 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** A. Definition and Explanation of Medicinal Chemistry Terms: HITS, lead compound, toxicity studies, high throughput screening B. Nomenclature of Drugs: 1. Introduction to IUPAC 2. Generic system 3. International non-proprietary names and trade names C. Historical perspectives: 1. Overview of development in medicinal chemistry in 20^{th} and 21^{st} century 2. Significance of medicinal chemistry D. Introduction to Modern Drug Discovery: 1. Rational drug design 2. Molecular modeling 3. Use of gene and DNA technology in chemotherapy E. Classification of Drugs Based on: 1. Therapeutic classes 2. Drug targets 3. Drug 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	15

	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)	
III	**Biopharmaceuticals** A. Regulations of Biopharmaceuticals: 1. Regulations and Sources 2. Regulatory authorities and their role: Food and Drug Administration (FDA), World Health Organization (WHO) and Clinical and Laboratory Standards Institute (CLSI) 3. Ministry of AYUSH in biopharmaceutics (introduction, role and guidelines) B. Pharmacopeia: 1. Introduction to pharmacopeia: IP, USP and BP (vision, mission, policy role and objectives) 2. Significance of IP with any one example in detail	15
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. Bioavailability 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 651 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 652 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 652 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** A. 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	15

	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	
III	**Applications of Bioprocess Technology** A. Upstream and Downstream Processing for the Following Microbial Metabolites: 1. Antibiotics (Rifamycin) 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, and U from ore and their bio-recovery 7. Probiotics and prebiotics: Fundamental aspects and health benefits	15
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 for 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 in the preparation of SOPs, operation and validation for analytical methods F. Entrepreneurship 1. Concept of entrepreneurship 2. Scope for entrepreneurship in Microbiology/Life sciences 3. Concept of incubation centre 4. Challenges and considerations for startups and small-scale industry	15

Suggested References for MB 652 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 653 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 653 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 653 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 660 MJ: Quality Assurance and Validation in the Pharmaceutical Industry and Development of Anti-infectives from Plants

Group I 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 660 MJ: Quality Assurance and Validation in the Pharmaceutical Industry and Development of Anti-infectives from Plants

Group I 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:	15

	1. Anti-mycobacterial agents 2. Anti-fungal agents 3. Anti-protozoal agents 4. Anti-viral agents	

Suggested References for MB 660 MJ: Quality Assurance and Validation in the Pharmaceutical Industry and Development of Anti-infectives from Plants Group I 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 660 MJP: Practicals Based on Quality Assurance and Validation in the Pharmaceutical Industry and Development of Anti-infectives from Plants
Group I 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 660 MJP: Practicals Based on Quality Assurance and Validation in the Pharmaceutical Industry and Development of Anti-infectives from Plants
Group I 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 660 MJP: Practicals Based on Quality Assurance and Validation in the Pharmaceutical Industry and Development of Anti-infectives from Plants
Group I 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.
4. McGuire J. and Kupiec T.C. (2007). Quality-control analytical methods: the quality of sterility testing. Int J Pharm Compounding. 11(1): 52–55.

5. Madsen R. E. (1994). US vs. Barr Laboratories: a technical perspective. PDA J Pharm Sci Tech. 48(4): 176–179.
6. Moldenhauer J. and Sutton S.V.W. (2004). Towards an improved sterility test. PDA J Pharm Sci Tech. 58 (6): 284–286.
7. Moldenhauer J. (2006). Viability-based rapid microbiological methods for sterility testing and the need for identification of contamination. PDA J Pharm Sci Tech. 60(2): 81–88.
8. Schroeder H. G. (2005). Sterility failure analysis. PDA J Pharm Sci Tech. 59(2): 89–95.
9. Sykes G. (1956). The technique of sterility testing. J Pharm Pharmacol. 8: 573
10. Lorian V. (1986). Antibiotics in laboratory medicine. 2nd Ed. Williams and Wilkins Publication
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 661 MJ: Advances in Microbial Technology
Group II 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 661 MJ: Advances in Microbial Technology
Group II 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	15

	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 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: 1. Heat and mass transfer 2. 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 661 MJ: Advances in Microbial Technology Group II 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). Biochemical 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 661 MJP: Practicals Based on Advances in Microbial Technology
Group II 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 661 MJP: Practicals Based on Advances in Microbial Technology
Group II 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 661 MJP: Practicals Based on Advances in Microbial Technology
Group II 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.

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7. Owens J.D. and Legan J.D. (1987). Determination of the Monod substrate saturation constant for microbial growth. FEMS Microbiology Reviews, 3(4):419–432. https://doi.org/10.1111/j.1574-6968.1987.tb02478.x
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9. Kovárová-Kovar K, Egli T. Growth kinetics of suspended microbial cells: from single-substrate-controlled growth to mixed-substrate kinetics. Microbiol Mol Biol Rev. 1998 Sep;62(3):646-66. doi: 10.1128/MMBR.62.3.646-666.1998
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MB 662 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 662 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	15

	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) 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 662 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.

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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 662 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 662 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 662 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

4. Srivastava A. K. (2003). Environment Impact Assessment, (A.P.H. Publishing. Corporation, Delhi, ISBN-817648-4423

5. Cruickshank R. (1982). Medical Microbiology, 12th Edition, P.403. 2. Felix A. (1942) Brit. Med. J. 11: 597.
6. Roitt L. (1994). Essential Immunology. 8th edition. Blackwell Scientific. Oxford, UK.114- 115.
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MB 663 MJ: Biosafety, Bioethics and Intellectual Property Rights
Group IV 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 663 MJ: Biosafety, Bioethics and Intellectual Property Rights
Group IV 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 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	15

Suggested References for MB 663 MJ: Biosafety, Bioethics and Intellectual Property Rights Group IV 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 663 MJP: Practicals Based on Biosafety, Bioethics and Intellectual Property Rights
Group IV 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 663 MJP: Practicals Based on Biosafety, Bioethics and Intellectual Property Rights
Group IV 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)	
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)	
3	FSSAI regulations - Microbiological testing of food: Detection and confirmation of *Listeria monocytogenes* in foods (at least two different samples)	
4	A case study on handling and disposal of biomedical waste from a hospital, a blood bank or any other suitable biomedical setting	
5	A case study on ethical issues related to clinical trials of drugs in India or abroad	
6	Proxy filing or thorough referencing of Indian Product patent	
7	Proxy filing or thorough referencing of Indian Process patent	
8	Visit to a hospital/blood bank/any other biomedical organisation to understand biosafety protocols followed	

Suggested References for MB 663 MJP: Practicals Based on Biosafety, Bioethics and Intellectual Property Rights
Group IV 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)
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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 681 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 681 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 the students can work independently and can 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, the student will write a thesis 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.