Title of the Program:

M.Sc. Microbiology

The Poona Gujarati Kelavani Mandal's

Haribhai V. Desai College of Arts, Science & Commerce (Autonomous)

Syllabus for

M.Sc. Microbiology Part –II

Affiliated to Savitribai Phule Pune University

To be implemented from Academic Year

2025-2026

1. Preamble:

The main theme of teaching microbiology course 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 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 Board of Studies in Microbiology has identified the following thrust areas and prospective plans for syllabi reforms at postgraduate level:

- **Microbial diversity**: Facets of microbial diversity which includes 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)
- **Cell and developmental Biology**
- **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 inclusion of 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 characterization and identification of bacteria
- Advanced Biochemistry techniques
- Advanced Molecular Biology Techniques
- Morphogenesis and organogenesis in plants
- Signal transduction
- Radioisotopes in Biology and Confocal Microscopy

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.

In the syllabus of Second year, the Board of Studies in Microbiology has identified the following thrust areas:

- Immunology: It includes recent BRM therapy, tumor and its microenvironment and also immunological tolerance.
- Molecular Biology: It includes concept and applications of genomics, proteomics and metabolomics.
- Clinical Microbiology: It includes understanding various bacterial, viral, fungal and protozoal diseases with respect to causative agents, general characters, detection methods and prophylaxis.
- Pharmaceutical Microbiology: It includes recent advancements in drug discovery and drug development.
- Bioprocess Technology: It includes the knowledge of the latest strategies in Bioprocess Technology.

2. Introduction:

With the changing scenario at local and global level, 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 of practical needs 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 in 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:

M.Sc. Programme is of 2 years duration. The minimum total no. of credits requirement for each programme is 88. In the structure, the credits are distributed over 4 semesters. The open elective included in each semester, gives the student a wide choice of subjects from other programmes.

Total credits:

A full masters' degree course in Science would be of 88 credits. One credit course of theory

will be of one clock hour per week, running for 15 weeks and one credit for practical course will consist of 30 clock hours of laboratory exercises. One credit is equivalent to one hour of teaching (theory) or two hours of practical work/field work per week. There shall be four semesters and credits are distributed over 4 semesters. There will be 2 core compulsory theory courses (4 credits each), one core compulsory theory course (2 credits) and one core compulsory Practical course (4 credits). In addition to this, choice based optional paper means elective courses are offered consisting of 2 theory credits courses and allied 2 practical credit courses. There are also Research Methodology (RM), Internship/ On the Job training (O/T) and Research Project credits assigned to a particular semester.

5. Credit Framework for Post Graduate (PG):

Credit Framework for Post Graduate (PG):

Level	Semester	Credits Related to Major		Research Methodology (RM)	Internship/ On Job Training (O/T)	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 2 Years		**54**	**16**	**4**	**4**	**10**	**88**
2 years-4 Sem. Award PG Degree on completion of 88 credits. After Three Years UG Degree or 1 Year- 2 Sem PG Diploma (44 credits) after Four Year UG degree							

6. Eligibility for Admission:

B.Sc. Microbiology. Eligibility to take admission for first year of M.Sc. program in the major subject is that the student has completed three-year bachelor degree in the same major.

7. Medium of Instruction: English

8. Award of Credits:

Each course having 4 credits shall be evaluated out of 100 marks and student should secure at least 40 marks (40%) to earn full credits of that course.

Each course having 2 credits shall be evaluated out of 50 marks and student should secure at least 20 marks (40%) to earn full credits of that course. GPA shall be calculated based on the marks obtained in the respective subject provided that student should have obtained credits for that course.

9. Evaluation Pattern:

Examination Rules

A student cannot appear for semester end examination unless he/she has maintained 75% attendance during the teaching period of that course. If a student fails to maintain attendance up to 75%, at the time of filling of examination forms, an undertaking from the student should be taken stating that he/she will be allowed to appear for examination subject to fulfillment of required attendance criteria during the remaining period of teaching of the course.
Each course carrying 100 marks shall be evaluated with Continuous Internal Assessment (CIA) and Semester End Examination (SEE).
Continuous Internal Assessment (CIA) shall be of 40 marks (40%) while the Semester End Examination (SEE) shall be of 60 marks (60%). To pass in a course, a student has to secure minimum 40 marks (40%) provided that he should secure minimum 24 marks (40%) in Semester End Examination and 16 marks (40%) in Continuous Internal Assessment.

Each credit will have a Continuous Internal Assessment of 40% of marks and a teacher must select a variety of procedures for examination such as:

a) Written Test and/or Mid Term Test (not more than one for each course)
b) Term Paper
c) Viva-voce
d) Projects / Surveys / Field visits
e) Tutorials
f) Group Discussion
g) Journal/Lecture/Library notes
h) Seminar presentation
i) Short Quizzes
j) Assignments
k) Extension Work
l) Research Project by individual students or group of students; or
m) An Open Book Test (with the concerned teacher deciding what books are to be allowed for this purpose on approval of the head of the centre).

If a student misses an internal assessment examination, he/she will have a second chance with the permission of the teacher concerned. Such a second chance shall not be the right of the student; it will be the discretion of the teacher concerned to give or not to give second chance to a student to appear for internal assessment.

The research project course will be evaluated on the basis of power point presentation and viva voce conducted at the end of semester.

Students who have failed Semester End Examination may reappear for the Semester End Examination in the subsequent period. The student will be finally declared as failed if he/she does not pass in all credits within a total period of four years in case of two-year courses and five years in case of three-year courses. After that, such students will have to seek fresh admission as per the admission rules prevailing at that time.

Internal marks will not change. A student cannot repeat internal assessment. In case he/she wants to reappear for the internal assessment he/she can do so only by registering for the said courses during the semesters in which the courses are being conducted.

There shall be revaluation of the answer scripts of semester-end examination of theory papers only but not of internal assessment papers as per Ordinance no 134 A and B.

10. ATKT Rules:

Minimum number of credits required to take admission to Second Year: 22 [50% of total credit in first year].

A student cannot register for the third semester, if he/she fails to complete 50% credits of the total credits expected to be ordinarily completed within two semesters. In this case, a student can seek admission to first or second semester in order to complete the requisite number of credits and to be able to seek admission in the third semester.

11. Completion of Degree Course:

A student, who earns 88 credits, shall be considered to have completed the requirements of the M. Sc. degree program and CGPA will be calculated for such student.

The following percentage to grade and grade point is given in Table 1 and calculation of SGPA and CGPA.

Table 1: Percentage to Grades and Grade Points

Sr. No.	Grade Letter	Grade Point	Marks
1	O (Outstanding)	10	90 ≤ Marks ≤ 100
2	A+ (Excellent)	9	75≤ Marks ≤89
3	A (Very Good)	8	60≤ Marks ≤74
4	B+ (Good)	7	55 ≤Marks ≤ 59
5	B (Above Average)	6	50≤ Marks ≤ 54
6	C (Average)	5	45≤ Marks ≤49
7	D (Pass)	4	40 ≤ Marks ≤44
8	F (Fail)	0	Marks < 40
9	Ab (Absent)	0	

Credit Point = (Credit x Grade point)

SGPA (Total Credit Point for Semester /Total Credit for the semester)

CGPA (Total Credit Point/Total Credit for the course)

12. Performance Indices:

The semester end grade sheet will contain grades for the courses along with titles and SGPA. Final grade sheet and transcript shall contain CGPA.

Semester Grade Point Average (SGPA) -The performance of a student in a semester is indicated by a number called the Semester Grade Point Average (SGPA). The SGPA is the weighted average of the grade points obtained in all the courses, seminars and projects registered by the student during the semester.

Course Grade Point Average (CGPA)- The CGPA is the weighted average of the grade points obtained in all the courses (Theory/term work/practica1/oral/presentation) of first semester to second semester for the students admitted in the First year and third to fourth semester for the students directly admitted at Second year. It is calculated in the same manner as the SGPA.

In case of a student passing a failed course or in case of improvement, the earlier grade would be replaced by the new grade in calculation of the SGPA and CGPA.

13. Result

Based on the performance of the student in the semester examinations, results will be declared.

Table 2: CGPA distribution and corresponding class of the degree awarded

Sr.No	CGPA	Class of the Degree awarded
1	9.50 or More than 9.50	Outstanding (O)
2	8.25 or more but less than 9.50	Excellent (A+)
3	6.75 or more but less than 8.25	Very Good (A)
4	5.75 or more but less than 6.75	Good (B+)
5	5.25 or more but less than 5.75	Above Average (B)
6	4.75 or more but less than 5.25	Average (C)
7	4.00 or more but less than 4.75	Pass (D)

14. Course structure & assessment of Credits: M. Sc. Second year Microbiology Semester III

MB: Microbiology; MJ-TH: Major Theory; MJ-PR: Major Practical; RP: Research Project

Course Type	Course Code		Course Name	Credit	Assessment		
					CIA	SEE	Total
Major Core Theory Papers	MB-601-MJ-TH		Immunology	4	40	60	100
	MB-602-MJ-TH		Molecular Biology II	4	40	60	100
	MB-603-MJ-TH		Clinical Microbiology	2	20	30	50
Major Core Practical Paper	MB-604-MJ-PR		Practicals based on MB-601, 602 & 603- MJ-TH	4	40	20	30
Research project	MB-631-RP-PR		Research Project-I	4	40	60	100
Major Elective (Theory + Practical) Papers (Choose any one group)	Group I	MB-610-MJ-TH	Cell Culture Techniques	2	20	30	50
		MB-611-MJ-PR	Practicals Based on MB-610- MJ-TH	2	20	30	50
	Group II	MB-612-MJ-TH	Bioremediation & Biomass Utilization	2	20	30	50
		MB-613-MJ - PR	Practicals Based on MB-612- MJ-TH	2	20	30	50
	Group III	MB-614-MJ-TH	Microbial Virus Technology	2	20	30	50
		MB-615-MJ-PR	Practicals based on MB-614- MJ-TH	2	20	30	50
	Group IV	MB-616-MJ-TH	Clinical Microbiology and Parasitology	2	20	30	50
		MB-617-MJ- PR	Practicals based on MB-616-MJ-TH	2	20	30	50

Course structure & assessment of Credits: -M. Sc. Second year Microbiology

Semester IV

MB: Microbiology; MJ- TH: Major Theory; MJ-PR: Major Practical; RP: Research Project

Course Type	Course Code		Course Name	Credit	Assessment		
					CIA	SEE	Total
Major Core Theory Papers	MB-651-MJ-TH		Pharmaceutical Microbiology	4	40	60	100
	MB-652-MJ-TH		Bioprocess Technology	4	40	60	100
Major Core Practical Paper	MB-653-MJ-PR		Practicals based on MB-651& 652-MJ-TH	4	40	60	100
Research Project	MB-681-RP-PR		Research Project- II	6	60	90	150
Major Elective (Theory + Practical) Papers (Choose any one group)	Group I	MB-660-MJ-TH	Quality Assurance & Validation in Pharma	2	20	30	50
		MB-661-MJ-PR	Practicals Based on MB-660-MJ-TH	2	20	30	50
	Group II	MB-662-MJ-TH	Advances in Microbial Technology	2	20	30	50
		MB-663-MJ-PR	Practicals Based on MB-662-MJ-TH	2	20	30	50
	Group III	MB-664-MJ-TH	Industrial Wastewater Treatment and Industrial Production of Vaccines	2	20	30	50
		MB-665-MJ -PR	Practicals based on MB-664-MJ-TH	2	20	30	50
	Group IV	MB-666-MJ-TH	Biosafety, Bioethics and Intellectual Property Rights	2	20	30	50
		MB-667-MJ-PR	Practicals based on MB-666-MJ-TH	2	20	30	50

Program Specific Outcomes (PSOs) for M. Sc. Microbiology	
PSO	**Program Specific Outcomes (PSOs)**
	Upon completion of this programme the student will be able to
PSO1	**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
PSO2	**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 non-verbal communication with a sound understanding of microbial science to effectively communicate ideas
PSO3	**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 andquantification methods using sophisticated techniques.
PSO4	**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 wastewater treatment processes.

MB-601-MJ-TH: 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 this 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

Credit	Credit Title and Contents	Number Credits	Number 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)	1	15
II	**Regulation of Immune Response** A. Immunological tolerance 1. Central and peripheral immune tolerance 2. T cell-mediated suppression of immune response	1	15

	3. Role of T reg cells B. Types of Immune Response Regulation 1. Regulation by antigen 2. Niels Jernes immune network theory, Role of immune network in regulation 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 (3H-thymidine) uptake method 2. MTT assay 3. Assays of cell death (51Cr 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, animal models for autoimmunity and AIDS	1	15
IV	**Tumor Immunology** A. Definition of Terms: 1. Neoplasm, malignancy, metastasis, transformation, angiogenesis and oncogenes 2. Cellular transformations during neoplastic growth B. Tumors Tumors of the lymphoid system (lymphoma, myeloma, Hodgkins disease and non-Hodgkin 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 2. Tumor vaccine therapy 2. CAR T cell therapy	1	15

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-TH: 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 this 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

Credit	Credit Title and Contents	Number Credits	Number 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	1	15
II	**Genetic Engineering and Genome Editing** A. DNA Amplification Approaches and Applications: 1. Polymerase Chain Reaction (principle; types of PCR – reverse transcription PCR, real-time PCR, colony PCR, digital droplet PCR) 2. Isothermal Amplification 3. PCR in molecular diagnostics (viral and bacterial) B. Gene Therapy and Gene Editing 1. Concepts of gene therapy and gene augmentation 2. Introduction to genome editing technologies (Zinc Finger Nucleases, conditional gene knockouts) 3. Applications of gene therapy in treatment of cancer C. Genetically Modified Organisms: 1. Genetically modified organisms-social issues, ethical issues & intellectual property rights related to GMOs 2. Transgenic animals and their applications in medicine – prevention, early detection and cure of diseases (GFP gene in GM Monkey) 3. Transgenic plants: and their applications in agriculture (BT Cry genes in GM Corn and mAB) 4. Advantages and disadvantages of GMOs	1	15
III	**Transposable Elements** A. Transposable Elements in Bacteria: 1. IS elements, composite transposons, integrons 2. Replicative and non-replicative transposons 3. Controlling elements in TnA, Tn5 and Tn10 transposition B. Transposons in Maize (Ac-Ds System) and *Drosophila* (P Elements)	1	15

	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		
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: Metabolome, Metabolomics, Metabolite profiling, Metabolome fingerprinting, Role of Biomarker in metabolomics 2. Applications of metabolomics 3. Metabolite separation and detection methods (GC, GC-MS LC-MS and NMR) 4. Metabolome projects of plant and human, Future perspective of metabolomics	1	15

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

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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

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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/) Volume I: Drug Discovery. Ed. Chorghade Mukund S. Wiley- Interscience, John Wiley and Sons Inc. USA. 405-424. 4. Baidoo E. E. K. (2019) Microbial Metabolomics: A General Overview. Methods Mol Biol. 1859:1-8. 5. Kathera C (2019) Microbial proteomics and their importance in Medical Microbiology. Recent Developments in Applied Microbiology and Biochemistry, 21-36. 6. Pandey A and Mann M (2000) Proteomics to study genes and genomes. Nature, 405:837. 7. Tang J. (2011) Microbial metabolomics. Curr Genomics. 12(6):391-403. 8. Villas-Bôas S. (2012) Katya Ruggiero Microbial Metabolomics CABI.

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MB-603-MJ-TH: 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 this 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 therapeutic agents
CO 6	Understand the modes of action of various therapeutic agents

Credit	Credit Title and Contents	Number Credits	Number 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 of bacteria 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)	1	15
II	**Medically Important Microorganisms** A. Microbial diseases with respect to general characters, pathogenesis, diagnosis, treatment and prophylaxis: *1. Helicobacter pylori* 2. *Mycobacterium tuberculosis*, *Mycobacterium leprae* 3. Human papilloma virus (HPV) 4. *Candida albicans / Candida auris* 5. *Entamoeba histolytica* B. Handling and Disposal of Infectious Material	1	15

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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-MJ-PR: Practicals based on MB-601, 602 & 603- MJ-TH
Major Core Practical Paper
Total: 4 Credits Workload: 30 hours. /Credit
(Total Workload: -4 credits x30 hrs=120 hrs in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO1	Perform and visualize immunodiffusion and immunoelectrophoresis
CO2	Determine antibody titer from the given sample
CO3	Understand the principle of transformation of plasmid and perform blue-white screening
CO4	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.

No.	Practical Title	Number of hours
1	Quantitative estimation of antigen/antibody by single radial diffusion	120
2	Quantitative estimation of antigen/antibody by rocket immuno-electrophoresis	
3.	Agglutination techniques: Determination of iso-antibodies titer	
4.	Isolation of RNA from bacteria	
5	Denaturing agarose gel electrophoresis : Visualization of isolated RNA by denaturing agarose gel electrophoresis	
6.	Transformation of the *E. coli* with standard plasmids	
7.	Detection of transformation by blue-white screening and calculation of transformation efficiency	
8.	Study of bacterial conjugation process and transfer of the gene of interest	
9.	Visit to institute/industry for demonstration of ELISPOT/CFT/FACS/animal inoculation/western blotting/ Gene sequencing	
10.	Manual designing of primer for a hypothetical gene Or Designing of primer for a hypothetical gene by using primer blast software	
11.	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	
12.	Isolation and identification of MDR bacterial pathogen isolated from clinical samples as per CLSI guidelines	
13.	Isolation of Candida sp.	
14.	Identification of Candida sp.	
15.	Demonstration of cultivation of viruses by egg inoculation technique with pocks detection	

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18. Designing of the primers using primer blast: https://www.ncbi.nlm.nih.gov/tools/primer-blast/

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-TH: 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 this 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

Credit	Credit Title and Contents	Number Credits	Number 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	1	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	1	15

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-611-MJ-PR: Practicals Based on MB-610-MJ-TH

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 this 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

Credit	Practical Title	No of hours
I	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	30
II	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 (2 P) 6. Analysis of cultured cells using software tools (Image J/FIGI)	30

References

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.
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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-612-MJ-TH: Bioremediation & 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 this 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

Credit	Credit Title and Contents	Number Credits	Number 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	1	15
II	**Biomass Utilization** A. Concepts in Biomass Utilization: 1. Need for measurement of biomass or production	1	15

	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		

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 6. Yoshimura A., Naka T. and Kubo M. (2007). SOCS proteins, cytokine signalling and immune regulation. Nature Reviews. Immunology. 7(6): 454-465

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MB-613-MJ-PR: Practicals Based on MB-612-MJ-TH
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 this course learners will be able to	
CO 1	Isolate microorganisms capable of biodegradation of xenobiotics
CO 2	Assess the and identify biodegradation potential of plastics by microbial strains
CO 3	Demonstrate the process of biodiesel production using microalgae
CO 4	Isolate bio-emulsifier-producing organisms for biodegradation application
CO 5	Analyze the potential of microbial biomass in the biosorption of textile dyes and heavy metals
CO 6	Produce compost using agro-waste

Credit	Practical Title	No of hours
I	1. Isolation of para-nitrophenol/azo-dye/pesticide/hydrocarbon microorganisms 2. Degradation of para-nitrophenol/azo-dye/pesticide/hydrocarbon using microorganisms (degradation of any two compounds) 3. Low-density plastic/bioplastic degradation using bacterial isolates 4. Biodiesel production using microalgae	30
II	5. Isolation of bio-emulsifier-producing organisms for degradation of aromatic compounds 6. Biosorption of textile dyes and heavy metals by using microbial biomass 7. Production of compost by using agro-waste	30

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multidisciplinary development unifying molecular biology, chemical, and electronics engineering. Biotechnol Adv. 25(1): 85-98.
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MB-614-MJ-TH: 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 this 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

Credit	Credit Title and Contents	Number Credits	Number 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	1	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 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	1	15

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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)
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virulent actinophages specific for *Streptomyces flavovirens*. Journal of Virology Research.
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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-615-MJ-PR: Practicals Based on MB-614-MJ-TH
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 this 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

Credit	Practical Title	No of hours
I & II	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) (2P) b. *In-vitro* use of lytic bacteriophages specific against *Klebsiella* spp. for prevention and dispersion of biofilm (microtitre plate assay)	60

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bioremediation of pathogen infested water bodies. PhD thesis, University of Pune, Pune, Maharashtra
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3. Hobbs Z. and Abedon S. T. (2016) Virology Diversity of phage infection types and associated terminology: the problem with Lytic or lysogenic. Minireview. FEMS Microbiology Letters, 363, , fnw047 doi: 10.1093/femsle/fnw047, 2016

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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
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MB-616-MJ-TH: 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 this 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

Credit	Credit Title and Contents	Number Credits	Number of Hours
I	**Clinical Microbiology** A. Clinical Specimen Handling and Acquired Infections: 1. Collection, transport, preservation and processing of various human clinical specimens in the laboratory.	1	15

	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		
II	**Parasitology** A. Introduction to Medical Parasitology: 1. Classification of parasites 2. Host-parasite relationships 3. Routes of infection 4. Effect of parasites on organs and tissues 5. Host response to parasite infections 6. Zoonoses B. Identification of Parasites in Stool: 1. Gross examination of stool 2. Microscopic examination for the presence of parasites 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*	1	15

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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.

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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-617-MJ-PR: Practicals Based on MB-616-MJ-TH
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 this 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

Credit	**Practical Title**	**No of hours**
I & II	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	60

References
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-PR: Research Project I
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 this 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

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.

5. Evaluation of Project Proposal:

The assessment of the project proposal will be for total of 100 marks (CA-30 and ESE-70) out of which the end semester will be for 70 marks and the continuous assessment will be for 30 marks.

The assessment of 30 marks will be carried out by the guide(s) who has supervised the work of the candidate(s) throughout the semester. The assessment will be carried out on the basis of the points, as per the accompanied format. Head of the department should communicate this point wise assessment system to the dissertation supervisor, well in advance. Guide(s) will give appropriate marks, point wise and submit it in a sealed envelope(s) to the Head of the respective department, three days prior to examination and project proposal presentation. On the day of examination, Head of the department will hand over these unopened envelopes to the examiners.

Assessment of remaining 70 marks (end semester examination) will be carried out for individual student at the time of examination jointly by Internal and External examiners by the means of oral presentation. The assessment will be carried out on the basis of the points as per the accompanied format of the mark sheet.

Students should be made aware of the assessment parameters, on which they will be assessed throughout the semester and at the end of the third semester

Point wise mark sheet – to be filled in by the Guide (Based on the evaluation carried out throughout the period of writing project proposal

Sr No.	Points of Evaluation	Max. Marks
1	Intellectual potential – Understanding of the research problem by the student (Topic selection)	5
2	Research aptitude – Depth of literature survey for the proposed work	10
3	Inputs of the student in development of plans and protocols for the experimentation (Methodology)	10
4	Motivation – punctuality, meeting dead-lines and seriousness (Attendance)	5
5	The project proposal preparation (Scientific writing) and its contents	10
	Total	**40**

Point wise mark sheet – to be filled in by Internal/ External examiner (Based on oral presentation and viva voce of the project proposal as end semester evaluation

Sr No.	Points of Evaluation	Max. Marks
1	Intellectual potential – Understanding of the research problem by the student	5
2	Proficiency of presentation skills – use of audio-visual aids, use of scientific language	5
3	The project proposal preparation (Scientific writing) and its contents	10
4	Abilities of satisfactory responses to the queries	10
Total		**30**

MB-651-MJ-TH: 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 this 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

Credit	Credit Title and Contents	Number Credits	Number 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 20th and 21st century 2. Significance of medicinal chemistry D. Introduction to Modern Drug Discovery: 1. Important steps in Modern Drug discovery 2. Pharmacovigilance E. Classification of Drugs Based on: 1. Therapeutic classes 2. Drug targets 3. Drug mechanisms of action	1	15
II	**Drug Development** A. Lead Optimization: 1. Lead likeness, drug likeness 2. Determination of biological and biochemical properties of drug B. Drug Designing: 1. Rational drug design 2. Molecular modeling 3. CADD, LBDD, SBDD (protein crystallography; molecular	1	15

	docking) C. Drug Development: 1. Preclinical development 2. Toxicity testing – acute, sub acute, chronic D. Clinical Development: 1. Clinical trials (aims, objectives and conduct,outcomes) 2. Clinical trial phases (0, I, II, III and IV)		
III	**Biopharmaceuticals** A. Regulations of Biopharmaceuticals: 1. Regulatory authorities and their role: Food and Drug Administration (FDA), World Health Organization (WHO) and Clinical and Laboratory Standards Institute (CLSI) 2. 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	1	15
IV	**ADME (Pharmacodynamics and Pharmacokinetics)** A. Passage of Molecules through Biological Barriers: Membrane transport (paracellular, transcellular) B. Drug Absorption: 1. Drug dosages 2. Gastric emptying to gastric permeability to drug 3. First-pass effect 4. Bioavailability 5.Factors affecting bioavailability C. Drug Distribution: 1. Drug-plasma/serum binding 2. Blood-brain barrier 3. Accumulations in various organs and tissues 4.Factors affecting Drug Distribution D. Drug Metabolism and Elimination: 1. Biotransformation reactions 2. Functionalization 3. Conjugation reaction 4. Reactions leading to toxic metabolites 5.Elimination of drugs,Factors affecting Elimination	1	15

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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

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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.

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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-TH: 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 this 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

Credit	**Credit Title and Contents**	**Number Credits**	**Number 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	1	15

	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		
II	**Process Variables and Monitoring** A. Process Variables: 1. Aeration theory of oxygen transfer in bubble aeration; Oxygen transfer kinetics (Oxygen Uptake Rate – OUR, Oxygen Transfer Rate OTR, Ccrit), determination of KLa value. 2. Agitation; Functions of agitation; Flow patterns with different types of impellers; Effect of agitation and microbial biomass on KLa value a. Fermentation broth rheology and power requirements for agitation – Concept of Newtonian and non-Newtonian fluids b. Effect of broth rheology on heat, nutrient and oxygen transfer c. Reynold‟s number, power number, aeration number: solving examples using different software programs B. Monitoring of Process Variables: 1. Use of various types of sensors and biosensors for monitoring environmental parameters (pressure, pH, temperature, DO and DCO2) 2. Basic principles of operation, types of biosensors	1	15
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. Probiotics and prebiotics: Fundamental aspects and health benefits	1	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	15

	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		

References	
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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-MJ-PR: Practicals Based on MB-651 & 652-MJ-TH
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 this 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

No	Practical Title	No of hours
1	Preparation of project proposal for start-up/small-scale industry in Microbiology/Life Sciences	120
2	Isolation of industrially important microbes (bacterial/fungal strains) producing citric acid/acetic acid or penicillin/streptomycin/tetracycline or any other suitable compound (2 Practicals)	
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 (2 Practicals)	
4	Production and recovery/purification of the above product from submerged fermentation (2 Practicals)	
5	Production and recovery/purification of bio-pigment/s using suitable bacterial/fungal culture (2 Practicals)	
6	Determination of substrate consumption rate (glucose) in batch culture using *E. coli*/*Bacillus* sp(2 Practicals)	
7	Determination of yield coefficient of cell biomass (*E. coli*/*Bacillus* sp.) using a suitable substrate (e.g. glucose) (2 Practicals)	
8	Microbial limit testing of any cosmetic /Pharamaceutical product using IP method	
9	Validation of disinfection procedure using a suitable disinfectant and any bacterial culture	

References

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MB-660-MJ-TH: Quality Assurance & Validation in the Pharma
-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 this 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

Credit	Credit Title and Contents	Number Credits	Number 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	1	15
II	**Development of Anti-infectives** A. Definitions: Therapeutic ratio, MIC and MBC B. Overview of Susceptibility Testing: 1. Use of liquid and solid media 2. Factors affecting susceptibility testing, CLSI guidelines 3. Diffusion methods – agar dilution technique, gradient plate techniques, E-test, Kirby Bauer method, Stokes method C. Susceptibility Testing for Following Agents 1. Anti-mycobacterial agents 2. Anti-fungal agents 3. Anti-protozoal agents 4. Anti-viral agents	1	15

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. 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 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-661-MJ-PR: Practicals Based on MB-660-MJ-TH

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 this 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	Apply extraction techniques to isolate and fractionate bioactive constituents from medicinal plants
CO 5	Evaluate the antimicrobial potential of bioactive extracts using standardized CLSI guidelines
CO 6	Perform qualitative detection of bioactive compounds from plants

Credit	Practical Title	No of hours
I	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	30
II	4. Extraction of bioactive principles from plants and activity fractionation (2 Practicals) 5. Estimation of its antimicrobial activity using standard guidelines (CLSI) (2 Practicals) 6. Qualitative detection of extracted bioactive principles from plant	30

References

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2. Indian Pharmacopoeia. (2007). Government of India, Ministry of Health and Family Welfare. The Indian Pharmacopoeia Commission. Ghaziabad. 1:53
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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-662-MJ-TH: 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 this 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	Apply kinetic models to describe microbial growth in batch, continuous, and fed-batch culture systems
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

Credit	Credit Title and Contents	Number Credits	Number 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	1	15
II	**Advances in Solid-state Fermentation** A. Concept of Solid-state Fermentation: 1. Introduction 2. List of examples in detail 3. Merits and demerits 4. Current developments B. Comparative Account of Liquid-state (surface and suspended culture) and Solid-state Fermentation in Detail C. Factors Affecting Solid-state Fermentation: 1. Inoculum type (microorganisms)	1	15

	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		

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 JanJun;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-663-MJ-PR: Practicals Based on MB-662-MJ-TH

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 this 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

Credit	Practical Title	No of hours
I	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	30
II	4. Laboratory scale production and media optimization for exopolysaccharide/bioemulsifier production (2 practicals) 5. Batch growth kinetics and establishment of key kinetic parameters(2 practicals) 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(2 practicals) 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	30

References

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MB-664-MJ-TH: 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 this 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

Credit	Credit Title and Contents	Number Credits	Number 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	1	15
II	**Industrial Production of Vaccines** A. Introduction to Vaccines B. Types of Vaccines: inactivated, attenuated, toxoid, subunit, conjugate, experimental, valence, heterotypic C. Production and Purification of the vaccines 1. Pilot and industrial-scale production 2. Excipients 3. Role of adjuvants and preservatives 4. Purification of vaccines D. Production of viral, bacterial and protozoal vaccines 1. Generations of vaccines 2. Subunit vaccines (Hepatitis B) 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	1	15

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I I	**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. 8 th 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-processtechnology.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_Scaleup_and_Manufacturing

MB-665-MJ-PR: Practicals Based on MB-664-MJ-TH
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 this 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

Credit	Practical Title	No of hours
I	1. Estimation of different solids (TS, TSS and TDS) from food/dairy/pharmaceutical industry wastewater (effluent) (any two different wastewater samples) (2 practicals) 2. Setting up a laboratory experiment to assess the degradability of synthetic wastewater(2 practicals)	30
II	3. Checking the potency of a toxoid-based vaccine by immune diffusion assay (2 practicals) 4. Preparation of *Salmonella* O and H antigens 5. Estimation of *Salmonella* O and H antigens with known antibodies	30

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MB-666-MJ-TH : 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 this 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

Credit	Credit Title and Contents	Number Credits	Number 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 bio containment (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)	1	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	1	15

References	
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	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.

MB-667-MJ-PR: Practicals Based on MB-666-MJ-TH

Group IV Major Elective Practical Paper

Total: 2 Credits | Workload: 30 hrs/credit

Course outcomes COs	
After studying the course learners will be able to	
CO1	Understand the importance of biosafety and its guidelines thoroughly
CO2	Gain knowledge of biological waste disposal in biomedical settings
CO3	Know the various Indian regulatory bodies concerning biosafety and their functions
CO4	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

No.	**Credit Title and Contents**	**Number of hours**
1	FSSAI regulations - Test methods for drinking water: Detection of sulphite-reducing anaerobes (clostridia) (at least two different samples)	60
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 organization to understand biosafety protocols followed	

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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)
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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-PR: Research Project II

Total: 6 Credits | Workload: 30 hrs/credit
(Total Workload: 6 credits × 30 hrs = 180 hrs in semester)

Course Outcomes (COs)	
After studying this 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

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 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.

4. Evaluation of Research Project:

The assessment of the dissertation is for total of 150 marks (CA-45 and ESE-105) out of which the end semester will be for 105 marks and the CA will be for 45 marks.

The assessment of 45 marks will be carried out by the guide(s) who has supervised the work of the candidate(s) throughout the semester. The assessment will be carried out on the basis of the points, as per the accompanied format. Head of the department should communicate this point wise assessment system to the dissertation supervisor, well in advance. Guide(s) will give appropriate marks, point wise and submit it in a sealed envelope(s) to the Head of the department, three days prior to examination and project presentation. Head of the department will hand over these unopened envelopes to the examiners.

Assessment of remaining 105 marks (end semester examination) will be carried out for individual student at the time of examination jointly by Internal and External examiners by the means of oral presentation. The assessment will be carried out on the basis of the points as per the accompanied format.

Students should be made aware of the assessment parameters, on which they will be assessed throughout the semester and at the end of the fourth semester.

Point wise mark sheet – to be filled in by the Guide (Based on the evaluation carried out throughout the period of dissertation

Sr No.	Points of Evaluation	Max. Marks
1	Understanding of the research problem by the student	10
2	Research aptitude –	
	a) Application of plans and protocols for the experimentation (Methodology)	10
	b) Ability to analyze data and formulate a solution	10
	c) Analytical and reasoning abilities of the student for interpretation of data, inputs in discussion	10
3	Motivation – punctuality, meeting dead-lines and seriousness (Attendance)	10
4	The dissertation report preparation (Scientific writing) and its contents	10
Total		**60**

Point wise mark sheet – to be filled in by Internal/ External examiner (Based on oral presentation and viva voce of the dissertation as end semester evaluation

Sr No.	Points of Evaluation	Max. Marks
1	Proficiency of presentation skills – use of audio-visual aids, preparation of graphs, charts, models, statistical analysis etc., use of scientific language	10
2	Research potential of the work, results and interpretation, outcome of the study and possible future plans, publication potential of the work towards society	15
3	The dissertation report preparation (Scientific writing) and its contents	10
4	Abilities of satisfactory responses to the queries	10
Total		**45**