Title of the Program:

M.Sc. (Microbiology) As per NEP 2020

Savitribai Phule Pune University

(*Formerly University of Pune*)

Faculty of Science and Technology

Revised Syllabi for

M.Sc. (Microbiology) Part-I

NEP 2020

For Colleges

Affiliated to Savitribai Phule Pune University

To be implemented from Academic Year 2023-2024

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.

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:

I. Total credits:

A full master's 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. 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.

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Credit Framework for Post Graduate (PG):

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

II. M. Sc. First year Microbiology Semester I assessment of Credits:

MB: Microbiology; MJ: Major Theory; MJP: Major Practical; ET: Elective Theory EP: Elective Practical; RMT: Research Methodology Theory; RMP- Research Methodology Practical

Components Study	Course Code		Course Name	Credit	Assessment		
					IA	UE	Total
Core Compulsory Theory Papers	MB 501 MJ		Microbial Systematic	4	30	70	100
	MB 502 MJ		Biochemistry, Cell, and Developmental Biology	4	30	70	100
	MB 503 MJ		Basic Quantitative Biology	2	15	35	50
Core Compulsory Practical paper	MB 504 MJP		Practical's based on MB 501 MJ Microbial Systematic, MB 502 MJ Biochemistry, Cell and Developmental Biology, and MB 504 MJP Basic Quantitative Biology	4	30	70	100
Research Methodology Theory	MB 531 RMT		Research Methodology	2	15	35	50
Research Methodology Practical	MB 531 RMP		Research Methodology	2	15	35	50
Choice Based Optional Papers Elective/ Departmental Course **Any one group**	Group I	MB 510 MJ	Microbial Extremophiles	2	15	35	50
		MB 510 MJP	Practical's Based onMB 510 MJ Microbial Extremophiles	2	15	35	50
	OR						
	Group II	MB 511 MJ	Microbial communication, Membrane transport and signal transduction approaches for Biologist	2	15	35	50
		MB 511 MJP	Practical's Based on MB 511 MJ Microbial communication, Membrane transport and signal transduction	2	15	35	50
	OR						
	Group III	MB 512 MJ	Advanced Quantitative Biology	2	15	35	50
		MB 512 MJP	Practical's based on MB 512 MJ Advanced Quantitative Biology	2	15	35	50
	OR						
	Group IV	MB 513 MJ	Experimental Design and Quantitative approaches for Biologist	2	15	35	50
		MB 513 MJP	Practical's based on MB 513 MJ Experimental Design and Quantitative approaches for Biologist	2	15	35	50

III. M. Sc. First year Microbiology Semester II assessment of credits:-

MB: Microbiology; MJ: Major Theory; MJP: Major Practical; ET: Elective Theory EP: Elective Practical; OJT- Internship/ On job training

Course Type	Course Code		Course Name	Credit	Assessment		
					IA	UE	Total
Core Compulsory Theory Papers	MB 551 MJ		Molecular Biology-I	4	30	70	100
	MB 552 MJ		Enzymology, Bioenergetics and Metabolism	4	30	70	100
	MB 553 MJ		Laboratory Techniques and Instrumentation	2	15	35	50
Core Compulsory Practical paper	MB 554 MJP		Practicals based on MB 551 MJ Molecular Biology I, MB 552 MJ Enzymology, Bioenergetics and Metabolism and MB 553 MJ Laboratory Techniques and Instrumentation	4	30	70	100
Internship/ On job training	MB 581 OJT		Internship / On job training	4	30	70	100
Choice Based Optional Papers Elective/ Departmental Course **Any one group**	Group I	MB 560 MJ	Molecular Biology tools and applications	2	15	35	50
		MB 560 MJP	Practical based on MB 560 MJ Molecular Biology tools and applications	2	15	35	50
	OR						
	Group II	MB 561 MJ	Nitrogen Metabolism, Respiration and Photosynthesis	2	15	35	50
		MB 561 MJP	Practicals based on MB 561 MJ Nitrogen Metabolism, Respiration and Photosynthesis	2	15	35	50
	OR						
	Group III	MB 562 MJ	Molecular Biophysics	2	15	35	50
		MB 562 MJP	Practicals based on MB 562 MJ Molecular Biophysics	2	15	35	50
	OR						
	Group IV	MB 563 MJ	Bioinformatics	2	15	35	50
		MB 563 MJP	Practicals based on MB 563 MJ Bioinformatics	2	15	35	50

IV. Course Evaluation:

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

V. Examination Results:

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

VI. The GPA:

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

VII. Rules and University Guidelines:

All other rules will be as per the university guidelines for postgraduate courses under credit-based system.

VIII. Important Note:

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

5. General Instructions:

The post-graduate degree will be awarded to students who obtain a total 88 credits (22 average credits per semester). One credit will be equivalent to 15 clock hours of teacher-student contact per semester.

Assessment shall consist of

a) In-semester continuous assessment and

b) End-semester assessment.

The teacher concerned shall announce the units for which each in-semester assessment will take place. However, the end-semester assessment shall cover the entire syllabus prescribed for the course. An in-semester assessment of 30% marks should be continuous and at least two tests should be conducted for courses of 4 credits and a teacher must select a variety of procedures for examinations such as:

1. Written test and/or midterm test (not more than one or two for each course)
2. Term paper
3. Journal/Lecture/Library notes
4. Seminar presentation
5. Short Quizzes
6. Assignments
7. Extension work
8. An open book test (with the respective subject teacher deciding what books are to be allowed for this purpose)

9. Mini research project by individual student or group of students

The concerned teacher in consultation with the Head of the PG Department shall decide the nature of questions for the unit test.

Semester end examination for remaining 70% marks will be conducted by Savitribai Phule Pune University. The student has to obtain 40% marks in the combined examination of In-semester assessment and Semester-End assessment with a minimum passing of 30% in both these separately.

To pass the degree course, a student shall have to get a minimum aggregate 40% marks (E and above grade point scale) in each course. If a student misses an internal assessment examination, he/she will have a second chance with the permission of the Principal in consultation with the concerned teacher. Such a second chance shall not be the right of the student.

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

A student cannot register for the third semester, if she/he fails to complete 50% credits of the total credits expected to be ordinarily completed within two semesters.

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

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

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

Program Specific Outcomes (PSOs) for M. Sc. Microbiology	
PSO No.	**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 and quantification 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 waste water treatment processes.

M. Sc. Microbiology Part I Semester I

MB 501 MJ: Microbial Systematics
Total: 4 Credits Workload :-15hrs/credit
(Total Workload:-4 credits x 15 hrs =60 hrs in semester)

Course Outcomes (COs)	
After studying this course learners will be able to	
CO1	Define species concept in prokaryotes and eukaryotes. List measures and indices of diversity. Define –unculturable' bacteria and list culture independent molecular methods. Identify unculturable bacteria. List different molecular methods used in microbial taxonomy.
CO2	Explain 5-Kingdom and 3 domain classification system and facets of microbial diversity. Understand molecular evolution. Explain Socio-biology and Lamarckism, Darwinism, Neo Darwinism & understand Game theory, r and k selection.
CO3	Apply the knowledge of molecular clocks in taxonomy. Summarize various theories of evolution.

Credit	Credit Title and Contents	Number Credits	Number of Hours
I	**Microbial Systematics:** 1. Species concept in prokaryotes and eukaryotes 2. Five-Kingdom classification system and Three-Domain classification system 3. Overview of fungal systematics and Differentiating characters among different Classes of fungi 4. Determinative Bacteriology (Phenetic Approach) and Systematic Bacteriology (Phylogenetic Approach) 5. Polyphasic Approach 6. Molecular clocks, phylogeny and molecular distances	1	15
II	**Microbial Diversity:** 1. Facets of microbial diversity: morphological, structural, metabolic, ecological, behavioral and evolutionary 2. Species divergence and measurement of microbial diversity 3. Measures and indices of diversity; alpha, beta and gamma diversity	1	15

III	**Exploration of Uncultured Microbial Diversity** 1. Concept of 'unculturable' bacterial diversity 2. Strategies for culture of 'unculturable' bacteria 3. Culture independent molecular methods for identifying unculturable bacteria (PCR, RFLP, ARDRA, DGGE, TGGE, RAPD, Microarray, FISH, RISA) 4. Methods of extracting total bacterial DNA from a habitat and metagenome analysis	1	15
IV	**Evolution:** 1. History and development of evolutionary theory (Lamarckism, Darwinism), Neo Darwinism: Spontaneous mutation controversy, evolution of rates of mutation, types of selection, levels of selection, group selection and selfish genes. 2. Socio-biology, kin selection, evolutionary stability of cooperation, sociality and multi- cellularity in microorganisms, Game theory. Co-evolutionary strategies, host parasite co- evolution 3. Molecular evolution: origin of life, the origin of new genes and proteins aging, evolutionary trade-offs, r and k selection	1	15

References

1. Barnett H. L. and Hunter B. B. (1960). Illustrated Genera of Imperfect Fungi. Burgess Publishing Co., Minnesota.
2. Black J. G. (2013). Microbiology: Principles and Explorations. 6th Edition. John Wiley & Sons, IncBromham L. and Penny D. (2003). The Modern Molecular Clock. Nat Rev Genet. 4(3):216-224. Nature Publishing Group.
3. Brown J. (2014). Principles of Microbial Diversity. ASM Press.
4. Buchanan, R. E. and Gibbons, N. E. (editors). 1974. Bergey's Manual of Determinative Bacteriology. 8th ed. Williams & Wilkins Co., Baltimore
5. Garrity G., Boone D. R. and Castenholz R. W. (2001). Bergey's Manual of Systematic Bacteriology. Volume One: The Archaea and the Deeply Branching and Phototrophic Bacteria. 2nd Edition. Springer-Verlag New York
6. Garrity G., Brenner D. J., Krieg N. R. and Staley J. R. (2005). Bergey's Manual of Systematic Bacteriology. Volume Two: The Proteobacteria, Part A: The Gamma proteobacteria. 2nd Edition. Springer-Verlag US
7. Garrity G., Brenner D. J., Krieg N. R. and Staley J. R. (2005). Bergey's Manual of Systematic Bacteriology. Volume Two: The Proteobacteria. Part B: Alphaproteobacteria.2nd Edition. Springer-Verlag US
8. Garrity G., Brenner D. J., Krieg N. R. and Staley J. R. (2005). Bergey's Manual of Systematic Bacteriology. Volume Two: Part C. the combination of the Beta-, Delta-

and Epsilon proteobacteria. 2nd Edition. Springer-Verlag US
9. Keller M. and Zengler K. (2004) Tapping in to Microbial Diversity. Nature Reviews. 2(2): 141-150
10. Kirk J. L., Beaudette L. A., Hart M., Moutoglis P., Klironomos J. N., Lee H. and Trevors J.T. (2004). Methods of studying soil microbial diversity. J Microbiol Methods. 58(2):169-188. doi: 10.1016/j.mimet.2004.04.006. PMID: 15234515.
11. Krieg N. R., Ludwig W., Whitman W., Hedlund B. P., Paster B. J., Staley J. T., Ward N., Brown, D. and Parte A. (Editors). (2010). Bergey's Manual of Systematic Bacteriology. Volume 4. 2nd Edition. Springer-Verlag New York
12. Lively C. M. (1996). Host-Parasite Coevolution and Sex: Do interactions between biological enemies maintain genetic variation and cross-fertilization? BioScience. 46 (2):107–114. https://doi.org/10.2307/1312813
13. Lodder J. (1974). The Yeasts: A Taxonomic Study. North Holland Publishing Co. Amsterdam.

MB 502 MJ: Biochemistry, Cell and Developmental Biology

Total: 4 Credits Workload: -15 hrs/ credit

(Total Workload:-4 credits x 15 hrs= 60 hrs in semester)

Course Outcomes (COs)	
After studying this course learners will be able to	
CO1	Understand the enzytme kinetics, the mechanisms of enzyme catalysis, and the mechanisms of enzyme regulation in the cell.
CO2	Conceive the concept of energy, cite examples and assess its importance to living organisms.
CO3	Understand metabolic pathways for various nitrogenous compounds.
CO4	Understand the properties of lipids at the chemical, molecular and biological levels that contribute to cellular function and diseases.
CO5	Know the chemistry of carbohydrates, their structures, conformations and reactivities.
CO5	Understand micronutrients and their importance.

Credit	**Credit Title and Contents**	**Number of Credits**	**Number of hours**
I	**Protein Chemistry:** 1. Structural features of amino acids, classification of amino acids, Amino acids as buffers 2. Henderson Hasselbalch equation and its role in buffer formulation. Peptide linkage, partial double bond nature of peptide bond 3. Determination of primary structure of polypeptide (N-terminal, C-terminal determination, method of sequencing of peptides). 4. Structural classification of proteins: primary, secondary, tertiary, quaternary structures of proteins, 5. Non-covalent interactions, Conformational properties of proteins, Polypeptide chain geometry, Resonance forms of the peptide group, cis/trans isomers of peptide group, Ramachandran plot. 6. Secondary, Super-secondary, Motif & Domain. 7. Tertiary and Quaternary structures of proteins, (Myoglobin & hemoglobin)	1	15
II	1. **Nucleic acid chemistry:** Structure of bases, nucleosides, nucleotides,	1	15

	phosphodiester linkages, 5' phosphate, 3' hydroxyl polarity of nucleic acids, tautomeric forms of bases and their implication in the pairing of bases, structure of DNA (A, B and Z forms), Tm value, Cot curves, structure of t-RNA, rRNA, m-RNA and other RNAs 2. **Carbohydrate Chemistry:** Mono, di, oligosaccharides, and polysaccharides, with examples, asymmetric center in sugars, D-series, L-series, dextro, laevo-rotatory, reducing and non-reducing sugars, sugar anomers, sugar epimers, sugar derivatives such as sugar alcohols, amino sugars, sugar acids, deoxy sugars. 3. **Lipid Chemistry**: Classification of lipids according to chemical structure, fatty acids, saturated, unsaturated, branched, nomenclature system, structure and function of triglycerides, phospholipids, sphingolipids, terpenes, prostaglandins, waxes, and steroids.		
III	**Developmental Biology:** 1. Introduction to developmental biology. Different model systems used to study developmental biology 2. Conserved nature of development, Concepts of commitment, determination and differentiation, 3. Morphogen gradients in developmental regulation, Hox code, MPF 4. Gastrulation and cellular movements involved in it, Organizer and its importance giving examples of invertebrates (*Drosophilla*) and vertebrate (*Xenopus*) model systems, pattern formation in body axis, antero-posterior and dorso-ventral polarity. 5. Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem; shoot and root development; transition to flowering, floral meristems and floral development in *Arabidopsis*.	1	15
IV	**Cell Biology:** 1. Structural organization and function of Endoplasmic Reticulum, Golgi apparatus, Nucleus, Mitochondrion, chloroplast, Lysosomes, peroxisomes; Cytoskeleton and function of Molecular motors. 2. Protein trafficking among various cellular compartments (by secretory and cytosolic pathway: targeting to secretory vesicles, cell membrane, lysosomes, nucleus, mitochondria and peroxisomes) 3. Events in cell cycle, Regulation of cell cycle. Apoptosis	1	15

References

Credit I and II:

1. Branden C. I. and Tooze J. (2012). Introduction to Protein Structure. United States: CRC Press. ISBN:9781136969898,
2. Garrett, R. H. and Grisham, C. M. (2004) Biochemistry. 3rd Ed. Brooks/Cole, Publishing Company, California.
3. Moat A. G., Foster J. W. and Spector M. P. (2003) Microbial Physiology. Germany: Wiley. ISBN: 9780471461197
4. Nelson D. L. and Cox M. M. (2021). Lehninger's Principles of Biochemistry.8thEdition. Mac Millan Worth Pub. Co. New Delhi. ISBN:9781319228002
5. Segel I. H. (2010). Biochemical Calculations. 2nd Ed. Wiley India Pvt. Limited. ISBN: 9788126526437
6. Tymoczko J. L., Gatto G. J., Stryer L. and Berg J. M. (2018). Biochemistry: A Short Course. United States: W. H. Freeman. ISBN: 9781319114633
7. Voet D. and Voet J. G. (2011). Biochemistry. United Kingdom: Wiley. ISBN: 9780470570951

Credit III: Development and Differentiation

1. Gilbert S. F. and Barresi M. J. F. (2020). Developmental Biology. United States: Oxford University Press. ISBN:9781605358222,
2. Müller W. A. (2012). Developmental Biology. United States: Springer New York. ISBN: 9781461222484.
3. Wolpert L., Tickle C. and Martinez Arias A. (2015). Principles of Development. United Kingdom: Oxford University Press. ISBN: 9780199678143

Credit IV: Cell Biology

1. Alberts B., Johnson A., Lewis J., Morgan D., Raff M., Roberts, K. and Walter P. (2015). Molecular Biology of the Cell. 6th edition. Garland Science; Taylor and Francis Group. New York. ISBN: 9781317563754
2. Lodish H., Berk A., Kaiser C. A., Krieger M., Bretscher A., Ploegh H., Martin K. C., Yaffe M. and Amon A. (2021). Molecular Cell Biology. 9th Edition. Macmillan Learning.ISBN: 9781319208523
3. Metzler D. E. and Metzler C. M. (2001). Biochemistry: The Chemical Reactions of Living Cells. Netherlands: Elsevier Science. ISBN: 9780124925410

MB 503 MJ: Basic Quantitative Biology

Total: 2 Credits Workload:-15 hrs/credit

(Total Workload:-2 credits x15 hrs = 30 hrs in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO1	Understand importance of statistics in biology.
CO2.	Understand basic terms used in statistics. Formulate a hypothesis for the experiment as well as test it using appropriate methods.
CO3	Know the methods for systematic collection and arranging different types of data.
CO4	Calculate basic statistical parameters and plot graphs by using data.
CO5	Calculate and interpret the observations by using tests used in inferential statistics.

Credit	Credit Title & Contents	Number of Credits	Number of hours
I	**Descriptive Statistics** 1.Fundamental concepts - Sample Statistics and Population parameter, data (qualitative and quantitative data, discrete and continuous series data) , variables, Measurement scales (nominal, ordinal, interval and ratio) 2.Collection and organization of data, tabulation, graphical representation (Histogram, frequency polygon and ogive curves, survival curves), diagrammatic representation (Simple bar diagram, percentage bar diagram, multiple bar diagram, sub-divided bar diagram and pie diagram). 3.Measures of central tendency – Mean, median , Percentile and mode; 4.Measures of dispersion – Mean deviation, Standard deviation and Variance; 5.Simple linear Regression and correlation	1	15
II	**Inferential Statistics-1** 1. Fundamental concepts –Central Limit Theorem, Distribution of sample mean, standard error and confidence interval 2. Probability- Classical definition and Axiomatic approach to definition of probability. Bayes theorem and Odd's ratio. 3. Concepts of null hypothesis, alternate hypothesis, significance level, p-value, type I and type II errors, one tailed and two tailed tests, degrees of freedom	1	15

	4. Parametric and nonparametric test- Comparative account 5. Parametric test (Mean and proportion)): t-tests and z test (*Biological examples/data should be used to apply the test*)		

References

1. Irfan Ali Khan and Atiya Khanum, Fundamentals of Biostatistics. 3rdEd. Ukaaz, Publications, Hyderabad.
2. Bernard Rosner, Fundamentals of Biostatistics, 5th Edition. Duxbur Thomson.
3. Wayne Daniel (2007), Biostatistics A foundation for Analysis in the health sciences, wiley In
4. Lindgren B.W. Statistical Theory, Macmillan Publishing Co. Inc.
5. Norman T.J. Bailey Statistical methods in biology, 3rdEd. Cambridge University Press
6. Gupta S.P. Statistical methods, Sultan Chand & Sons Publisher, New Delhi
7. Montgomery D.C. Design and analysis of experiments, John Wiley & Sons
8. Stephen Newman, Biostatistical methods in Epidemiology. Wiley Inter science Publication,
9. Aviva Petrie and Carolene Sabin, 2005, Medical Statistics at a glance, 2ndEdition, Blackwell.
10. David Brown & Peter Rothery. Models in biology: Mathematics, statistics, and computing John Wiley &Sons, USA.
11. Practical Fermentation Technology Edited by Brian Mc Neiland LindaM.Harvey 2008 John Wiley & Sons, Ltd. ISBN:978-0-470-01434-9
12. Sundar Rao, Richard J, (2012), Introduction to Biostatistics and Research Methods,5th edition, PHI Learning Pvt ltd.

MB 504 MJP: **Biochemical Techniques (Compulsory Practical Paper)**

Total: 4 Credits Workload:-30hrs /credit

(Total Workload:-4 credits x 30 hrs=120 hrs in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO1	Follow and appreciate protocols and practices in the laboratory as per the standards for successful practical completion.
CO2.	Understand various methods to prepare biological buffers.
CO3	Know the effective ways of presentation of biological data and its statistics using software.
CO4	Use microbiological procedures required for isolation, characterization and identification of microbes.
CO5	Understand methods for visualization of cell division.
CO6	Understand the basic aspects of developmental biology.
CO7	Use methods for extraction of microbial biomolecules and their estimation and understand the computational aspect of protein structures.

Credit Title and Contents	Number of Credits	Number of hours
1. Safety rules in Laboratory: Laboratory safety, hazard from chemicals, handling of chemicals, disposal of chemicals and cultures, recording of scientific experiments. 2. Standardization of laboratory procedures, calibration and validation instruments, preparing /designing SOP for the same, maintenance of instruments. 3. Buffer: Determination of pKa of a monoprotic weak organic acid by titration and graph method. 4. Preparation of buffer using KH_2PO_4 and K_2HPO_4. 5. Preparation of buffer using acetic acid and sodium acetate. 6. Preparation of buffer using K_2HPO_4 and H_3PO_4. 7. Computer applications: Using datasheets, and sorting data with different parameters, plotting graphs – bar charts, line graphs, pie charts, adding error bars. (Using Microsoft Excel) 8. Statistical analysis of data – Students t test. 9. Enrichment, Isolation and identification of the following from natural samples: Gram negative bacteria. 10. Enrichment, Isolation and identification of the following from	4	120

natural samples: Gram positive bacteria. For Practical 9 and 10 identifications of the bacteria to at least the Genus level using the Bergey's Manuals is expected. The identification key must be designed for each isolated and identified bacterium. Students are expected to isolate at least one Genus from each group. *(At least 5 different types of samples should be processed to obtain isolates*) 11. Studying the stages of mitosis in the growing tip of onion root cells. 12. Studying and observing polyploidy induced by colchicin treatment on Onion root tip. 13. Demonstration of mounting embryo fruit fly at various developmental stages on permanent slides. 14. Extraction of Protein using TCA from bacterial culture. 15. Extraction of Exo-polysaccharide from Microbial culture using organic solvent. (may use ethanol method) 16. Spectrophotometry: estimation of above extracted protein sample: Bradford and UV-Spectrophotometry. 17. Spectrophotometry: estimation of above extracted EPS sample: Phenol Sulphuric Acid method. 18. Interpretation of Ramchandran Plot and study of conformations of protein molecule using Molecular Graphics Visualization Tool (e.g. Swiss PDB)		

References

Safety rules in Laboratory

- Fuscaldo A. (2012). Laboratory Safety Theory and Practice. United Kingdom: Elsevier Science.
- Leboffe M. J. and Pierce B. E. (2010). Microbiology Laboratory theory and Application. Chapter 1. Introduction: Safety and laboratory guidelines. 3rd edition. Morton Publishing Company. 1-8.
- Plummer M. and Plummer D.T. (2001). Introduction to practical biochemistry. 3rd Edition, Tata McGraw- Hill Edition.
- United States Environmental protection agency (EPA), EPA QA/G-6. 2007. Guidance for preparing SOP. 1-6.
- World Health Organization Staff, World Health Organization. Laboratory Biosafety Manual, 3/Ed. (2006). India: AITBS Publishers.
- https://www.labmanager.com/lab-health-and-safety/science-laboratory-safety-rules-guidelines-5727

Buffer:

- Jayaraman J. (2004). Laboratory Manual in Biochemistry. India: New AgeInternational (P)

Limited Publishers.

- Plummer M. and Plummer D.T. (2001). Introduction to practical biochemistry. 3rd Edition, Tata McGraw- Hill Edition.
- Sadasivam S. and Manickam A. (2008). Biochemical methods. 3rd Edition, New Age International Publishers, India.
- Segel I. H. (2010). Biochemical Calculations, 2nd Edn. India: Wiley India Pvt. Ltd.

Computer applications:

- Conner N. and MacDonald M. (2013). Office 2013: The Missing Manual. United States: O'Reilly Media.
- McFedries P. (2019). Microsoft Excel 2019 Formulas and Functions. PearsonEducation.
- https://www.britannica.com/technology/spreadsheet

Statistical analysis of data –

- Boslaugh S. (2012). Statistics in a Nutshell. Germany: O'Reilly Media Incorporated.
- McFedries P. (2019). Microsoft Excel 2019 Formulas and Functions. Pearson Education
- Salkind N. J. (2016). Statistics for People Who (Think They) Hate Statistics: Using Microsoft Excel 2016. United States: SAGE Publications.

Enrichment, Isolation and identification of the following extremophiles from natural samples: Gram positive and Gram Negative

- Mohammad B. T., Al Daghistani H. I., Jaouani A., Abdel-Latif S. and Kennes C. (2017). "Isolation and characterization of thermophilic bacteria from Jordanian hot springs: *Bacillus licheniformis* and *Thermomonas hydrothermalis* isolates aspotential producers of thermostable enzymes". International Journal of Microbiology. 2017: Article ID: 6943952. 1-12. https://doi.org/10.1155/2017/6943952
- Nakatsu C. H., Miller R. V., Yates M. V. and Pillai S. D. (2020). Manual of Environmental Microbiology. United States: Wiley. ISBN:9781555818821

Studying the stages of mitosis in growing tip of onion root cells and to observe polyploidy induced by colchicine treatment on root tip.

- Manzoor A., Ahmad T., Bashir M. A., Hafiz A. and Silvestri C. (2019). Studies on colchicine induced chromosome doubling for enhancement of quality traits in ornamental plants. Plants.8:194. Doi: 10.3390/plants8070194.

Demonstration of mounting of embryos (fruit fly) at various developmental stages on permanent slides

- Gilbert S. F. and Barresi M. J. F. (2020). Developmental Biology. United States: Oxford

University Press.

- http://egyankosh.ac.in/bitstream/123456789/16459/1/Unit-25.pdf

Extraction of Protein and Exo-polysaccharide

- Bajpai V. K., Majumder R., Rather I. A. and Kim K. (2016). "Extraction, isolation and purification of exopolysaccharide from lactic acid bacteria using ethanol precipitation method". Bangladesh journal of pharmacology. 11(3): 573-576. doi: 10.3329/ bjp.v11i3.27170

Colorimetry and spectrophotometry:

- Jayaraman J. (2004). Laboratory Manual in Biochemistry. India: New Age International (P) Limited Publishers.
- Plummer M. and Plummer D.T. (2001). Introduction to practical biochemistry. 3rd Edition, Tata McGraw- Hill Edition.
- Prasad S., Mandal I., Singh S., Paul A., Mandal B., Venkatramani R. and Swaminathan R. (2017). Near UV-Visible electronic absorption originating from charged amino acids in a monomeric protein. Chem. Sci. 8: 5416 —5433. Royal Society for Chemistry.
- Sadasivam S. and Manickam A. (2008). Biochemical methods. 3rd Edition, New Age International Publishers, India.
- https://www.ruf.rice.edu/~bioslabs/methods/protein/abs280.html

Interpretation of Ramachandran

- Bansal M. and Srinivasan N. (2013). Biomolecular Forms and Functions: A Celebration of 50 Years of the Ramachandran Map. Singapore: World Scientific.
- Bourne P. E. (2011). Structural Bioinformatics. Germany: Wiley.
- Ramachandran G.N., Ramakrishnan C. and Sasisekharan V. (1963). Stereochemistry of Polypeptide Chain Configurations. J. Mol. Biol. 7: 95-99
- Pazos F. and Chagoyen M. (2014). Practical Protein Bioinformatics. Germany: Springer International Publishing

MB 510 MJ: Microbial Extremophiles
Group I Major Elective Theory
Total: 2 Credits Workload :-15hrs./credit
(Total Workload:-2 credits x 15 hrs. = 30 hrs.in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO 1	Understand extremophiles - microorganisms surviving under harsh conditions.
CO 2	Know the applications of extremophiles at industrial level.
CO 3	Understand the mechanisms of surviving of extremophiles under harsh conditions.
CO 4	Know different classes of extremophiles.

Credit	Credit Title and Contents	Number of Credits	Number of hours
I	**Microbial Extremophiles I** 1. Diversity of Extremophiles 2. Microbial forms of extremophiles in various habitats. 3. Sample Collection, Enrichment, isolation, classification, 4. Properties, and application of extremophiles: Thermophiles, Psychrophiles, Acidophiles and Alkaliphiles 5. Adaptation mechanisms of extremophiles	1	15
II	**Microbial Extremophiles II** 1. Sample Collection, Enrichment, isolation, classification, properties, and application of extremophiles: Halophiles, Piezophiles (Barophiles), Xerophiles and Oligophiles 2. Adaptation mechanisms of extremophiles 3. Biotechnological Applications of extremophilic Bacteria 4. Recent developments in extremophilic Bacteria	1	15

References

Credit I: Microbial Extremophiles I

1. Gerday C. and Glansdorff N. (2009). Extremophiles. United Kingdom: Eolss Publishers. ISBN: 9781905839933
2. Horikoshi K., Stetter K. O., Antranikian G., Robb F. and Bull A. (2010). Extremophiles Handbook. Germany: Springer.
3. Satyanarayana, T. & Raghukumar, C & Shivaji, Sisinthy. (2005). Extremophilic microbes:

Diversity and perspectives. Current science. 89. 78-90.

4. Sharma V. and Salwan R. (2020). Physiological and Biotechnological Aspects of Extremophiles. Netherlands: Elsevier Science. ISBN: 9780128183236

Credit II: Microbial Extremophiles II

1. Subba Rao D. V. and Durvasula R. V. (2018). Extremophiles: From Biology to Biotechnology. United States: CRC Press. ISBN: 9781351650731
2. Stan-Lotter H., Oren A. and Seckbach J. (2013). Polyextremophiles: Life Under Multiple Forms of Stress. Netherlands: Springer Netherlands.
3. Coker JA. (2016) Extremophiles and biotechnology: current uses and prospect. F1000 Research. 5:396 (https://doi.org/10.12688/f1000research.7432.1)
4. Zhu Daochen, Adebisi Wasiu Adewale, Ahmad Fiaz, Sethupathy Sivasamy, Danso Blessing, Sun Jianzhong, Recent Development of Extremophilic Bacteria and Their Application in Biorefinery , Frontiers in Bioengineering and Biotechnology, 8 (2020) 1-18, ISSN=2296-4185
5. Merino Nancy, Aronson Heidi S., Bojanova Diana P., Feyhl-Buska Jayme, Wong Michael L., Zhang Shu, Giovannelli Donato, Living at the Extremes: Extremophiles and the Limits of Life in a Planetary Context, Frontiers in Microbiology, 10 (2019) 1-25, ISSN=1664-302X

MB 510 MJP: Practicals based on MB 510 MJ Microbial Extremophiles
Group I Major Elective Practical

Total: 2 Credits Workload:-15hrs. /credit
(Total Workload:-2 credits x 30 hrs. = 60hrs in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO 1	Understand the technical details pertaining to samples required for isolation of extremophilic microbes.
CO 2	Know the methods to isolate and identify extremophilic microbes from different sources such as thermophiles / psychrophiles / acidophiles.
CO3	Know the methods to isolate and identify extremophilic microbes from different sources such as halophiles / alkaliphiles / oligophiles.
CO4	To build identification key for extremophilic microbes.
CO5	Identify extremophilic microbes using such keys.

Credit	**Credit Title and Contents**	**Number of Credits**	**Number of hours**
I	**Microbial Extremophiles I: (Thermophiles/Psychrophiles/Acidophiles)** 1. Sample Collection, Processing and Isolation 2. Morphological characterization of indigenous isolates based on staining techniques 3. Identification using Biochemical Tests *(Using Bergey's Manual)* 4. (At least 4 different types of samples should be processed to obtain representative isolate of the groups)	1	30
II	**Microbial Extremophiles II: (Halophiles/Alkaliphiles/Oligophiles)** 1. Sample Collection, Processing & Isolation 2. Morphological characterization of indigenous isolates based on staining techniques 3. Identification using Biochemical Tests *(Using Bergey's Manual)* (At least 4 different types of samples should be processed to obtain representative isolate of the groups)	1	30

References

Isolation and identification of the following extremophiles from natural samples: Acidophiles: -

1. Joe S. J., Suto K., Inoie C. and Chida T. (2007). Isolation and characterization of acidophilic heterotrophic iron-oxidizing bacterium from enrichment culture obtained

from acid mine drainage treatment plant. J BiosciBioeng. 104(2):117-123. doi: 10.1263/jbb.104.117.

2. Ňancucheo I., Rowe O. F., Hedrich S. and Johnson D. B. (2016). Solid and liquid media for isolating and cultivating acidophilic and acid-tolerant sulfate-reducing bacteria, FEMS Microbiology Letters, 363: 10, fnw083. https://doi.org/10.1093/femsle/fnw083
3. Sánchez-Andrea I., Stams A. J., Amils R. and Sanz J. L. (2013). Enrichment and isolation of acidophilic sulfate-reducing bacteria from Tinto River sediments. Environ Microbiol Rep. 5(5): 672-678. doi: 10.1111/1758-2229.12066

Halophiles: -

4. Gupta S., Sharma P., Dev K., Srivastava M. and Sourirajan A. (2015). A diverse group of halophilic bacteria exist in Lunsu, a natural salt water body of Himachal Pradesh, India. Springer Plus 4: 274. https://doi.org/10.1186/s40064-015-1028-1
5. Kumar S., Karan R., Kapoor S., Singh S. P. and Khare S. K. (2012). Screening and isolation of halophilic bacteria producing industrially important enzymes. Braz J Microbiol. 43(4): 1595–1603. doi: 10.1590/S1517-838220120004000044
6. Yeannes M. I., Ameztoy I. M., Ramirez E. E. and Felix M. M. (2011). Culture alternative medium for the growth of extreme halophilic bacteria in fish products. Food Science and Technology. 31(3): 561-566. https://doi.org/10.1590/S0101-20612011000300002

MB 511 MJ: Microbial communication, Membrane transport and signal transduction
Group II Major Elective Theory

Total:2 Credits Workload :-15hrs./credit
(Total Workload:-2 credits x 15 hrs. = 30 hrs.in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO 1	Understand the quorum sensing phenomenon with molecular mechanisms in Myxobacteria.
CO 2	Develop insights of quorum sensing in Gram negative and Gram positive bacteria.
CO 3	Acquainted with formation and dispersal of biofilm and extrapolate applications of biofilm in pathogenic and nonpathogenic bacteria.
CO 4	Gain in depth knowledge of membrane dynamics, architecture and composition and solute and ion mediated transport mechanisms.
CO5	Get knowledge about the signal transduction mechanism and chemotaxis in Microorganisms.

Credit	**Credit Title. and Contents**	**Number of Credits**	**Number of hours**
I	**Communication and Coordination among microorganisms** 1. Life cycle of *Dictyostelium discoideum*, Molecular mechanism of quorum sensing in slime molds, 2. Life cycle of myxobacteria, Molecular mechanism of quorum sensing in myxobacteria. 3. Quorum sensing in Gram positive and Gram-negative bacteria 4. Biofilms, their organization, signals involved in their formation and dispersal 5. Applications of study on biofilms in pathogenic and non-pathogenic environments	1	15
II	**Membrane transport and signal transduction** 1. The composition and architecture of membranes, Membrane dynamics 2. Solute transport across membranes: Passive diffusion, facilitated transport, primary and secondary active transport using P, V and F type ATPases 3. Ionophores, Ion mediated transport, transport of ions across membranes (ion pumps), ligand and voltage gated ion channels 4. Liposomes and model membrane Signal transduction pathways in bacteria, second messengers, regulation of signaling pathways, bacterial two-component systems, chemotaxis.	1	15

References

Credit I : Communication and Coordination among microorganisms

1. Gilbert S. F. (2010). Developmental Biology. 9th Ed. Sinauer Associates Inc. Mass. USA.
2. Dworkin M. (1996) Recent advances in the social and developmental biology of the myxobacteria, Microbiological Reviews: 70–102
3. Dale K., Mark R. and Lee K. (2010) Myxobacteria, Polarity, and MulticellularMorphogenesis, Cold Spring Harb Perspect Biol 2010; 2: a000380
4. Toole 'O' G., Kaplan H. B. and Kolter R. (2000) Biofilm formation as microbial development Annual Review of Microbiology: 54: 49-79.
5. Miller M. B. and Bassler B. L. (2001) Quorum sensing in bacteria. Annu. Rev.Microbiol. 55: 165–99.
6. Waters C. M. and Bassler B. L. (2005) Quorum sensing: cell-to-cell communication in bacteria. Annu. Rev. Cell Dev. Biol. 21: 319–346.

Credit II: Membrane transport and signal transduction

1. Alberts B., Johnson A., Lewis J., Morgan D., Raff M., Roberts, K. and Walter P. (2015) Molecular Biology of the Cell. 6th edition. Garland Science; Taylor and Francis Group.New York. ISBN: 9781317563754
2. Cantley L. C., Sever R. and Hunter T. (2014). Signal Transduction: Principles, Pathways, and Processes. United States: Cold Spring Harbor Laboratory Press.
3. Changeux J., Comoglio, P., Sandhoff, K., Schatz G., Pinna L., Tager J., Orrenius S., Jaenicke R. (2012). Biochemistry of Cell Membranes: A Compendium of Selected Topics. Switzerland: Springer Basel AG.
4. Evangelopoulos A.E., Changeux J.P., Wirtz K.W.A., Packer L. and Sotiroudis T.G. (2013). Receptors, Membrane Transport and Signal Transduction. Germany: Springer Berlin Heidelberg.
5. Fairweather I. Cell Signaling in Prokaryotes and Lower Metazoa. (2004). Germany: Springer Netherlands.
6. Pabst G. (2014). Liposomes, Lipid Bilayers and Model Membranes: From Basic Research to Application. United Kingdom: Taylor & Francis.
7. Sperelakis N. (2012). Cell Physiology Source Book: Essentials of Membrane Biophysics. Netherlands: Elsevier Science.
8. Stein W. D. and Litman T. (2014). Channels, Carriers, and Pumps: An Introduction to Membrane Transport. Netherlands: Elsevier Science.
9. Wardhan R. and Mudgal P. (2018).Textbook of Membrane Biology.Singapore: Springer Singapore

MB 511 MJP: Practicals Based on MB 511 MJ Microbial communication, Membrane transport and signal transduction

Group II Major Elective Practicals

Total:2 Credits Workload :-15hrs./credit

(Total Workload:-2 credits x 30 hrs. = 60 hrs.in semester)

Course outcomes:

Course outcomes COs	
After studying the course learners will be able to	
CO 1	Gain insights into the biofilm formation and determination of quorum sensing signals in bacteria.
CO 2	Understand chemotaxis response by various methods
CO 3	Know the mechanism of osmosis and diffusion with effect of various physical and chemical factors.
CO 4	Comprehend the details of cell disruption methods and effect of transport by swab testing.

Credit	Credit Title and Contents	Number of Credits	Number of hours
I	**Practicals Based on Credit I: Microbial Communication and Coordination among microorganisms** 1. Crystal violet assay for estimation of biofilm formation 2. Bioassay for determination of quorum sensing signals produced by bacteria. 3. Determination of chemo-taxis responses shown by bacteria using agar plate or capillary tube method.	1	30
II	**Practicals Based on Credit II: Membrane transport and signal transduction** 1. Study principles of osmosis and diffusion using artificial membranes (dialysis membrane) (explain how various physical and chemical factors affect the diffusion) 2. Different methods of cell disruption. 3. Swab evaluation with respect to transport of bacterial sample	1	30

References

Practical based on Credit I: Microbial Communication and Coordination among microorganisms

1. Crystal violet assay for estimation of biofilm formation:

- O'Toole G. A. (2011) Microtiter dish biofilm formation assay. Journal of Visualized Experiments. 47:3–5. doi: 10.3791/2437.
- Merritt J. H., Kadouri D. E. and O'Toole G. A. Growing and analyzing static biofilms. Curr. Protoc. Microbiol. 2006 doi: 10.1002/9780471729259.mc01b01s00.

2. Bioassay for determination of quorum sensing signals produced by bacteria:

- Martín-Rodríguez A. J. and Fernández J. J. (2016). A bioassay protocol for quorum sensing studies using *Vibrio campbellii*. Bio Protoc. 6: e1866
- Papenfort K. and Bassler B. (2016). Quorum sensing signal-response systems in Gram-negative bacteria. Nat. Rev. Microbiol. 14:576–588. 10.1038/nrmicro.2016.89.

3. Determination of chemo-taxis responses shown by bacteria.using agar plate or capillary tube method:

- Law A. M. J., Aitken M. D. (2005). Continuous-flow capillary assay for measuring bacterial chemotaxis. Appl. Environ. Microbiol.71: 3137–3143. 10.1128/AEM.71.6.3137-3143.2005,

Practical based on Credit II: Membrane transport and signal transduction

4. Study principles of osmosis and diffusion using artificial membranes (dialysis membrane) (explain how various physical and chemical factors affect the diffusion):

- Ravindra Babu B., Rastogi N.K. and Raghavarao K.S.M.S. (2006). Effect of process parameters on transmembrane flux during direct osmosis. Journal of Membrane Science. 280(1–2): 185-194
- Stillwell W. (2016). Membrane Transport. An Introduction to Biological Membranes. 23–451. doi: 10.1016/B978-0-444-63772-7.00019-1. PMCID: PMC7182109

5. Different methods of cell disruption:

- https://microbenotes.com/cell-disruption-methods/
- Islam M. S., Aryasomayajula A. and Selvaganapathy P. R. (2017). A Review on Macroscale and Microscale Cell Lysis Methods. Micromachines (Basel). 8(3): 83. doi: 10.3390/mi8030083 Swab evaluation with respect to transport of bacterial sample:
- Human R. P. and Jones G. A. (2004). Evaluation of swab transport systems against a published standard. J Clin Pathol. 57:762–763. doi: 10.1136/jcp.2004.016725.

MB 512 MJ Advanced Quantitative Biology
Group III Major Elective Theory

Total:2 Credits Workload :-15 hrs /credit
(Total Workload:-2 credits x 15 hrs = 30 hrs in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO 1	To appreciate the variation among the independent and dependent variables.
CO 2	Use the method of treatment of numerical biological data from different populations to evaluate the variation among them.
CO 3	Understand and analyse the relationship between outcome and several predicts or variables in biology.
CO 4	Appreciate the difference among analysis of qualitative and quantitative data.
CO 5	Know the techniques to analyze the data based upon categorical variables in biology.
CO 6	Understand the Methodology to determine the relation among qualitative variables in biology.

Credit	Credit Title and Contents	Number of Credits	Number of hours
I	**Inferential Statistics-2** 1. Test of Significance: Chi square test (Goodness of fit and Independence), 2. Comparison of 3 or more samples – ANOVA (One way and two- way), Post Hoc test (Tukey's test) 3. Nonparametric Tests: comparison to parametric tests, Sign test, Wilcoxon's signed rank test and Mann-Whitney U test, Run test. *(Biological examples/data should be used to apply the test)*	1	15
II	**Probability and Probability Distribution** 1. Concept of experiment, event (mutually exclusive & non-exclusive events, dependent & independent events); 2. Laws of probability (addition and multiplication), Combinations and permutations 3. Probability distribution – Normal (x-scale and z-scale), Binomial and Poisson distributions *(Biological examples/data should be used)*	1	15

References	
1.	Irfan Ali Khan and Atiya Khanum, Fundamentals of Biostatistics.3rd Ed. Ukaaz, Publications, Hyderabad.
2.	Bernard Rosner. Fundamentals of Biostatistics, 5thEd.Duxbury Thomson
3.	Wayne Daniel (2007) Biostatistics A foundation for Analysis in the health sciences, wiley

In
4. Feller W. Introduction to probability theory and its applications, Asia Publishing House, Mumbai
5. Lindgren B.W. Statistical Theory, Macmillan Publishing Co.I nc.
6. Norman T. J. Bailey Statistical methods in biology, 3rdEd. Cambridge University Press
7. Gupta S.P. Statistical methods, Sultan Chand & Sons Publisher, New Delhi
8. Montgomery D.C. Design and analysis of experiments, John Wiley & Sons
9. Sundar Rao, Richard J, (2012), Introduction to Biostatistics and Research Methods,5th edition, PHI Learning Pvt ltd.
10. Stephen Newman, Biostatistical methods in Epidemiology. Wiley Inter science Publication,
11. Aviva Petrie and Caroline Sabin,2005, Medical Statistics at a glance, 2nd Edition, Blackwell
12. Haefner James W. (1996). Modeling Biological Systems: Principles and Applications, Kluwer Academic Publications
13. David Brown & Peter Rothery. Models in biology: Mathematics, statistics, and computing John Wiley & Sons, USA
14. Practical Fermentation Technology Edited by Brian McNeil and Linda M. Harvey 2008 John Wiley & Sons, Ltd. ISBN:978-0-470-01434-9

MB 512 MJP : Practicals Based on MB 512 MJ Advanced Quantitative Biology
Group III Major Elective Practical
Total:2 Credits Workload :-30hrs/credit
(Total Workload:-2 credits x 30 hrs =60 hrs in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO 1	Appreciate the way the biological variables are distributed in nature.
CO 2	Understand the methodology of experimentation in biology and generation of the data.
CO 3	Know the methods of processing the biological data and make inferences.
CO 4	Use different softwares to process the numerical data and its interpretation.

Credit Title and Contents	Number of Credits	Number of hours
1. Analysis of data using parametric and non-parametric tests, comparison of results and interpretation (*using hypothetical data*). 2. Study the effect of environmental factors pH, temperature, salt, sugar (any two factors) on growth of bacteria using statistical tests (*Experimentation, data collection, analysis of data using suitable statistical technique and interpretation should be carried out).* 3. Applications of probability distribution (Normal, Binomial and Poisson distributions) to analyze the data 4. Computer applications: Statistical analysis of data – t-Test, ANOVA, Chi square test, F test using computer softwares (*Using Microsoft Excel or other software*)	2	60

References

1. Irfan AliKhan and Atiya Khanum, Fundamentals of Biostatistics.3rd Ed.Ukaaz, Publications, Hyderabad.
2. Bernard Rosner Fundamentals of Biostatistics, 5thEd.Duxbury Thomson
3. Wayne Daniel (2007) Biostatistics A foundation for Analysis in the health sciences, wiley In
4. Feller W. Introduction to probability theory and its applications, Asia Publishing House, Mumbai
5. Lindgren B.W. Statistical Theory, Macmillan Publishing Co.Inc.
6. NormanT.J. Bailey Statistical methods in biology, 3rdEd. Cambridge University

Press
7. Gupta S.P. Statistical methods, Sultan Chand & Sons Publisher, NewDelhi
8. Montgomery D.C. Design and analysis of experiments, John Wiley & Sons
9. Sundar Rao, Richard J, (2012), Introduction to Biostatistics and Research Methods, 5th edition, PHI Learning Pvt ltd.
10. Stephen Newman, Biostatistical methods in Epidemiology. Wiley Inter science Publication,
11. Aviva Petrie and Caroline Sabin,2005, Medical Statistics at a glance, 2nd Edition, Blackwell
12. Haefner James W. (1996), Modeling Biological Systems: Principles and Applications, Kluwer Academic Publications
13. David Brown & Peter Rothery. Models in biology: Mathematics, statistics, and computing John Wiley & Sons, USA
14. Practical Fermentation Technology Edited by Brian McNeiland Linda M. Harvey 2008 John Wiley & Sons, Ltd. ISBN:978-0-470-01434-9

MB 513 MJ: Experimental Design and Quantitative approach for Biologists
Group IV Major Elective Theory

Total: 2 Credits Workload:-15hrs/credit
(Total Workload:-2 credits x 15 hrs=30 hrs in semester)

Course outcomes COs	
After studying the course learners will be able to	
Credit I:	
CO 1	Gain knowledge about research methodology in detail.
CO 2	Hypothesize the probabilistic statements and make predictions about the data under study.
CO 3	Able to identify, select, and tabulate data under study.
CO 4	Able to learn experimental designs and understand improved process and able to build confidence making informed decisions about the data.
CO 5	Understand the relationships between multiple input and output variables.
CO 6	Understand the term epidemiology, will also be able to use, comment and criticize various epidemiological methods.
Credit II	
CO 1	Understand the basics about numbers..
CO 2	Perform comparative study about different types of mathematical functions.
CO 3	Correlate exponential function and bacterial growth.
CO 4	Correlate exponential function and bacterial death.
CO 5	Understand the mathematical basis of 12-D concept in autoclaving.
CO 6	Apply differentiation and integration in biology.
CO 7	Apply mathematical and computational skills in real life.

Credit	**Credit Title and Contents**	**Number of Credits**	**Number of hours**
I	**Design of Experiments:** 1. Sampling methods (Random and non-random), sampling errors 2. Survey design, DOE in Agriculture, principles (randomization, replication and local control), types of experimental designs (CRD, RCBD and LSD) 3. Factorial design (Full, Fractional and Plackett Burman) 4. Epidemiological Study designs: Case control, cohort,	1	15

	concurrent, cross-sectional, retrospective/prospective 5. Clinical/field trials-Randomization, Bias removal (Blinding single and double), controlled and uncontrolled trials		
II	**Quantitative approach for Biologists** 1. Concept of Real numbers and Imaginary numbers (1 lecture) 2. Dependent and Independent variables and concept of Mathematical Function, symbolic representation of function as f(x) etc. 3. Different types of Functions: a) Linear Function: properties of linear functions, graphical representations. Examples in Biology (e.g. all estimations using extrapolation of measurements on graphs, linear growth of microbes $\log N=\log N_0+ K_t$ and many more) b) Exponential Function: properties of exponential functions, graphical representations. Examples in Biology (bacterial growth, thermal inactivation of microbes mathematical basis of 12 D concept in autoclaving, radioactive decay) c) Power Function: Exponential Function: properties of power functions, graphical representations. Examples in Biology rate kinetics where more than one substrate molecules bind to multimeric enzymes, kinetics of binding of bivalent or multivalent antibodies to antigen) 4. Introduction to Differentiation and Integration. Applications in Biology. Note: No descriptive questions on this syllabus. Only solving the problems.	1	15

References

1. Montgomery D.C. Design and analysis of experiments, JohnWiley & Sons
2. David Brown & Peter Rothery. Models in biology: Mathematics, statistics, and computing JohnWiley & Sons, USA.
3. Bioprocess Engineering Principles by Pauline M. Doran (1995), Elsevier Science & Technology Books, ISBN:0122208552
4. Haefner James W. (1996) Modeling Biological Systems: Principles and Applications, Kluwer Academic Publications
5. Park K. (2019), Park's Textbook of Preventive and social Medicines, 25th edition, Banarsidas Bhanot publishers, ISBN: 978-93-82219-15-6.
6. Irfan Ali Khan and Aiya Khanum, Fundamentals of Biostatistics. 3rdEd. Ukaaz, Publications, Hyderabad.
7. Wayne Daniel (2007) Biostatistics A foundation for Analysis in the health sciences, wiley.
8. MATHEMATICS for the Biological Sciences by Jagdish C Arya; Robin W. Lardner Published by Prentice-Hall, Inc US.

MB 513 MJP : Practicals Based on MB 553 MJ Experimental Design and Quantitative approach for Biologists

Group IV Major Elective Practical

(Elective)

Total:2 Credits Workload:-30 hrs /credit

(Total Workload:-2 credits x 30 hrs=60 hrs in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO 1	Prepare the research proposal as per the standards.
CO 2	Prepare the epidemiological study proposal, and carry out investigation as per the standards and analysis of the data.
CO 3	Select the appropriate design for an experiment and do statistical analysis of the responses using software.
CO 4	Use the mathematical calculations for preparation of solutions.
CO 5	Solve, interpret and give proper treatment to the mathematical problems based on biological applications.
CO 6	Understand the biological data and its statistical analysis with the aid of software.

Credit Title & Contents	Number of Credits	Number of hours
Practicals based on theory credit Design of experiments 1. Designing Mock Research Proposal which includes: a) Title b) Hypothesis c) Review of Literature d) Methodology *(Specify Statistical Methods)* e) Possible outcomes *(Statistical Interpretations)* f) References *(Scientific writing should be followed for Research proposal)* 2. Epidemiological study Proposal *(Mini Project)* a) Identification of Problem and Establishing Hypothesis b) Selection of Design c) Data Collection d) Data Analysis e) Data Presentation f) Conclusion *(Scientific writing should be followed for proposal)* 3. Statistical Survey a) Identification of Problem and Establishing	1	30

Hypothesis b) Survey Design (Questionnaire based) c) Preparation of Questionnaire d) Data Collection e) Data Analysis f) Data Presentation g) Conclusion of Survey *(Actual statistical survey need to be carried out to demonstrate its mechanism*) 4. Factorial Study Design (Plackett-Burman, Fractional Factorial and full factorial) for Optimization of Media conditions a. Data collection from Research Papers/Dissertations/Journals b. Data Treatment using Statistical Software's (Microsoft Excel, Minitab, SPSS and Design Expert) *(Sr.no.1 is compulsory, select any one from sr.no.2 to 4)*		
Practicals based on theory credit Quantitative approach for Biologists 1. Numerical Microbiology: Problem solving: Unit conversion, preparation of standard solutions (Wt/V, V/V, %, Normal solution, Molar solutions etc.), Numerical Problems on size, volume, number (CFU and PFU), dilutions, Neubauer chamber, direct Microscopic count, Numerical Problems on Bacterial Growth. Numerical problems on diversity indices. 2. Computer applications: Using data sheets, and sorting data with different parameters, plotting graphs–bar charts, line graphs, pie charts, adding error bars. Statistical analysis of data – Students t test, ANOVA, Chi square test, F test using computer software *(Using Statistical Packages*)	1	30

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1. Montgomery D.C. Design and analysis of experiments, JohnWiley & Sons 2. David Brown & Peter Rothery. Models in biology: Mathematics, statistics, and computing JohnWiley & Sons, USA. 3. Bioprocess Engineering Principles by Pauline M. Doran (1995), Elsevier Science & Technology Books, ISBN:0122208552 4. Haefner James W. (1996) Modeling Biological Systems: Principles and Applications, Kluwer Academic Publications 5. Park K. (2019), Park's Textbook of Preventive and social Medicines, 25th edition, Banarsidas Bhanot publishers, ISBN: 978-93-82219-15-6. 6. Irfan Ali Khan and Aiya Khanum, Fundamentals of Biostatistics. 3rdEd. Ukaaz, Publicatior Hyderabad. 7. Wayne Daniel (2007) Biostatistics A foundation for Analysis in the health sciences, wiley. 8. MATHEMATICS for the Biological Sciences by Jagdish C Arya; Robin W. Lardner Publish by Prentice-Hall, Inc US.

M. Sc. Microbiology Part I Semester II

MB 551 MJ Molecular Biology I

Compulsory Theory Paper

Total:4 Credits Workload :-15 hrs /credit

(Total Workload :-4 credits x15 hrs=60 hrs in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO 1	Understand the basic differences between the Eukaryotic and the Prokaryotic Genome organization-working.
CO 2	Understand the regulation of Eukaryotic and Prokaryotic Gene expression with examples.
CO 3	Apply recombinant DNA technology and genetic engineering in the field of molecular Biology.
CO 4	Analyze and evaluate the molecular diagnostic techniques and its applications.

Credit	Credit Title & Contents	Number of Credits	Number of hours
I	1. Prokaryotic Genome organization, DNA replication, Mutagenesis and DNA repair. 2. Eukaryotic Genome organization, DNA replication and recombination, Chromatin remodeling, Histone modification and its effect on the function of chromatin, C value paradox, Rot and Cot concept, pseudogenes, 3. Transcription and Regulation in Prokaryotes and Eukaryotes: RNA polymerases, transcription unit, positive and negative regulation, role of attenuators, anti-termination	1	15
II	1. Prokaryotic and Eukaryotic translation: role of initiation factors, Shine-Dalgarno sequences, Kozak sequence, translocation of ribosomes, Role of elongation factors, termination codons and role of release factors, fidelity of translation, Puromycin translation assay. 2. Eukaryotic RNA Processing: i. mRNA splicing (Spliceosome and auto splicing by Intron I and Intron II); rRNA processing; tRNA processing; RNA Editing, ii. Nuclear export of mRNA iii. Regulatory RNAs and noncoding RNAs: Si RNA, Micro RNA, RNA interference (RNAi) iv. CRISPER-cas system. 3. Molecular Techniques: yeast two and three hybrid assay, Activity gel assay, DNA helicase assay, Chromatin Immuno-precipitation (ChIP), Designing probe, Epitope tagging	1	15

III	1. Enzymes used in Recombinant DNA technology; Restriction endonuclease, DNA ligase, T4 DNA polymerase, Terminal transcriptase, Alkaline phosphatase, polynucleotide kinase 2. Cohesive and blunt end ligation, linkers; adaptors; homopolymeric tailing labeling of DNA: 3. Nick translation, random priming, radioactive and nonradioactive probes 4. Hybridization techniques: Northern, Southern, south-western and far-western and colony hybridization, fluorescence in situ hybridization. 5. Vectors for cloning and gene expression: i. Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Blue script vectors, Baculovirus and Pichia vectors, plant-based vectors (Ti and Ri as vectors). Vectors for gene expression: types (pMal, GST, pET-based vectors), 6. Construction of genomic DNA and cDNA libraries; Human and *E.coli* genome project: introduction and applications. Concept of comparative genomics	1	15
IV	Molecular diagnostics and applications 1. Introduction to Microarray and array techniques, the lab-on-a-chip concept 2. Use of array techniques detection of polygenic diseases and diseases-associated changes in gene expression 3. Detection of RNA signatures of 'Antibiotic Resistance' in bacteria 4. Detection of microRNA (mi RNA): A signature of cancer diagnostics	1	15

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MB 552 MJ : Enzymology, Bioenergetics and Metabolism

Compulsory Theory Paper

Total: 4 Credits Workload :-15 hrs /credit

(Total Workload :- 4 credits x15 hrs = 60 hrs in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO1	Gain the knowledge of purification methods of enzymes. They will be able to define the terms related to thermodynamics. They will be able to draw structure of hormones.
CO2	Understand the Kinetics of enzyme reactions and gain knowledge of role of enzyme inhibitors.
CO3	Write metabolic pathways with respect to carbohydrate and lipid metabolism. They will be able to solve problems based on enzyme kinetics, purification and thermodynamics.
CO4	Construct a purification chart. Students will be able to compare anabolic reactions and catabolic reactions of carbohydrate metabolism. They will also be able to understand the synthesis of lipids and degradation of lipids.
CO5	Get information about types and functions of micronutrients.
CO6	Summarize types of cooperativity and models of allosteric enzymes.

Credit	Credit Title & Contents	Number of Credits	Number of hours
I	**Enzymology** 1. Overview: Purification of enzyme, purification chart 2. Overview: MM Equation and Kinetic Plots. 3. Kinetics of reversible inhibitions: Competitive, uncompetitive, non-competitive, mixed, substrate. Primary and secondary plots, Determination of Ki using secondary plots. Significance of inhibitors	1	15

	4. King Altman approach to derive – two substrate enzyme catalyzed reactions 5. Concept of allosterism, positive and negative cooperativity, models of allosteric enzymes (Monad, Wyamann and Changeux and Koshland, Nemethy and Filmer model), kinetics of allosteric enzymes, Hill plot, examples of allosteric enzymes and their significance in regulation.		
II	**Bioenergetics and Biosynthesis of Nitrogenous Compounds** 1. Overview: Laws of thermodynamics, entropy, enthalpy, free energy, and equilibrium constant with reference to biological significance. 2. Gibbs free energy equation. 3. Determination of free energy of hydrolytic and biological oxidation reduction reactions under standard and non-standard conditions 4. Overview of High Energy Compounds 5. Coupled reactions 6. Determination of feasibility of reactions 7. Problems based on 2, 3 and 6. 8. Atkinson's energy charge. 9. Biosynthesis of five families of amino acids and histidine, 10. Biosynthesis of purine and pyrimidine bases	1	15
III	**Lipid and Carbohydrate Metabolism** 1. Synthesis of lipids: Phospholipids and triacylglycerols, 2. Synthesis of membrane lipids: Glycerophospholipids, sphingolipids, sterols 3. Degradation of fatty acids (alpha, beta and Omega oxidation and unsaturated fatty acids) 4. Lipids as signal molecules (eg. phosphatidylinositol, eicosanoids). 5. Overview of Glycolysis and gluconeogenesis 6. Regulation of glycolysis and gluconeogenesis 7. Synthesis of microbial exopolysaccharides (alginate) 8. Cellulose synthesis and breakdown 9. Regulation of Glycogen synthesis & breakdown, 10. Metabolic flux and its regulation by various metabolic intermediates, 11. TCA cycle- regulation, role in energy generation, Role in generating biosynthetic intermediates and glyoxylate cycle	1	15
IV	**Micronutrients and Hormones** A. Structure, function of following micronutrients in metabolism 1. Water soluble vitamins and their coenzyme forms (Niacin, Riboflavin, Pantothenic acid, Thiamine, Pyridoxal, Vitamin B_{12}, Folic acid, Glutathione) 2. Fat soluble vitamins (A, D, E, and K) 3. Minerals as vitamins (Iron, Manganese, Magnesium, Cobalt, Molybdenum, Copper, Zinc, Nickel	1	15

	B. The chemical structure and functions of each hormone in connection with the gland responsible for its production: 1. The parathyroid 2. The pancreas 3. The adrenals 4. The pituitary glands 5. Sex hormones		

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MB 553 MJ: Laboratory Techniques and Instrumentation

Compulsory Theory Paper

Total: 2 Credits Workload: -15 hrs /credit

(Total Workload: -2 credits x15 hrs = 30 hrs in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO 1	Understand basic techniques and instrumentation in laboratory.
CO 2	Learn application of electromagnetic spectrum.
CO 3	Gain detailed knowledge of Biomolecules.
CO 4	Gain technical knowledge of spectroscopy.

Credit	Credit Title & Contents	Number of Credits	Number of hours
I	**Separation and analysis of biomolecules** 1. Techniques for sample preparation: Dialysis, ultra-filtration, centrifugal vacuum concentration 2. Chromatography Partition Coefficient, Selectivity, Resolution, Column Efficiency, Van Deemter equation, Interpretation of chromatograms, Principle, instrumentation and application gel filtration, Ion exchange, affinity chromatography, High-Performance Liquid Chromatography (HPLC), Fast Protein Liquid Chromatography (FPLC), Supercritical Fluid Chromatography, Reversed Phase Chromatography and Gas chromatography. 3. Electrophoresis Methods: Agarose, Native PAGE, SDS PAGE, Pulse field gel electrophoresis, capillary electrophoresis, isoelectric focusing, 2-dimensional electrophoresis, immune-electrophoresis	1	15
II	**Spectroscopy** Introduction: Electromagnetic spectrum, Atomic orbitals, Molecular orbitals, Electronic, Rotational, and Vibrational transitions in spectroscopy, Interpretation of spectra. 1. UV/Visible spectroscopy Instrumentation, Molar Absorptivity, Beer and Lambert's Law, Bathochromic and hypochromic shifts. 2. Fluorescence spectroscopy-Instrumentation, Quantum Yield, Quenching, FRET, Binding and Folding studies, Flow cytometry and FACS 3. Infrared spectroscopy Principle, Instrumentation, Absorption bands, FTIR and its applications 4. Mass spectroscopy- Principles of operation, Ionization, Ion fragmentation, Mass Analysers	1	15

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MB 554 MJP: Practicals based on MB 551 MJ, MB 552 MJ, MB 553 MJ
Compulsory Practical Paper

Total:4 Credits Workload :-30 hrs/credit
(TotalWorkload:-4 credits x 30 hrs= 120 hrs in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO 1	Understand various molecular Biology techniques which includes study of DNA RNA, proteins etc.
CO 2	Know the preparation of standard solutions, calculations and preparation s for cellular extraction of biomolecules and Purification.
CO 3	experience a hands-on approach and the troubleshooting during processing of th biomolecules.
CO 4	have an insight in the usage of bioinformatics and data bases in gene annotation procedure.

Credit Title & Contents	Number of Credits	Number of hours
1. Plasmid DNA isolation, DNA quantitation and characterization by gel electrophoresis. 2. Construction of restriction digestion map of plasmid DNA 3. Curing of bacterial Plasmid 4. Gene annotation 5. Isolation and characterization of lipase/cellulase/chitinase producing microbe 6. Purification of enzymes using ammonium sulphate precipitation/ Gel Filtration, Establishment of enzyme purification chart 7. Purification of enzymes using organic solvent precipitation, Establishment of enzyme purification chart 8. Determination of Km, Vmax and Kcat values of enzyme 9. Determination of molar extinction coefficient of biomolecule 10. Isolation of Aflatoxin producing organism. Extraction and detection of Aflatoxin in food. 11. Demonstration of SDS-PAGE for purification of proteins 12. Paper and thin layer chromatography technique for the separation of the amino acids from biological sample. 13. Paper and Thin layer chromatography technique for separation of the Sugars from biological sample (two dimensional). 14. Virtual lab exercise to understand the instrumentation,	4	120

experimentation and interpretation of data obtained using MALDI TOF 15. Virtual lab exercise/ Visit to understand the instrumentation, experimentation and interpretation of microscopy data (SEM, TEM, AFM).		

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MB 560 MJ: Molecular biology tools and applications
Group I Major Elective Theory

Total:2 Credits Workload:-15 hrs /credit

(Total Workload :-2 credits x 15 hrs= 30 hrs in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO 1	Explain principle and procedures of various molecular techniques.
CO 2	Explain the concept of microarray.
CO 3	Describe various hybridization techniques.
CO 4	Explain the concept of recombinant DNA technology.
CO5	Describe the use of Biopolymers.

Credit	Credit Title & Contents	Number of Credits	Number of hours
I	Credit I: Tools in Molecular Biology 1. Study of protein-DNA interactions: electrophoretic mobility shift assay; DMS foot printing, DNase foot printing; methyl interference assay, protein-protein interactions using yeast two hybrid systems; phage display. 2. DNA microarray, Construction of microarrays – genomic arrays, cDNA arrays and oligo arrays 3. Super shift assay and EMSA, Sequence tagged sites, Filter binding assay, Protein foot printing, finding the replicon, DNA	1	15

	fingerprinting, Measuring transcription rates 4. Hybridization techniques: Free solution, membrane based (DOT blot, SLOT blot), Fluorescence in situ hybridization (FISH) and Microarray technology,		
II	Applications of recombinant DNA technology in production of : 1. Synthesis of commercial products: Amino acids (L-Valine and L-cysteine), ascorbic acid, Peptide antibiotics, 2. Hybrid Human-Mouse monoclonal antibodies, Human monoclonal antibodies, anti-cancer antibodies 3. Biopolymers: gum, rubber, polyhydroxy alkanoates. 4. Un-conventional microbial systems for production of high quality protein drug	1	15

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22. Stormo G. (2013). Introduction to Protein-DNA Interactions: Structure, Thermodynamics, and Bioinformatics. United States: Cold Spring Harbor Laboratory Press.
23. Strohl L. M. and Strohl W. R. (2012). Therapeutic Antibody Engineering: Current and Future Advances Driving the Strongest Growth Area in the Pharmaceutical Industry. United Kingdom: Elsevier Science.
24. Travers A. A. and Buckle M. (2000). DNA-protein Interactions: A Practical Approach. United Kingdom: Oxford University Press.
25. Voet D. and Voet J. G. (2011). Biochemistry. United Kingdom: Wiley. ISBN: 9780470570951
26. Walsh G. (2013). Pharmaceutical Biotechnology: Concepts and Applications. Germany: Wiley.

MB 560 MJP: Practicals based on MB 560 MJ
Group I Major Elective Practical

Total:2 Credits Workload :- 15 hrs /credit
(Total Workload :-2 credits x30 hrs=60 hrs in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO 1	Explain principle and procedures of various molecular techniques.
CO 2	Explain the concept of microarray.
CO 3	Describe various hybridization techniques.
CO 4	Explain the concept of recombinant DNA technology.
CO5	Describe the use of Biopolymers.

Credit Title & Contents	Number of Credits	Number of hours
1. Cloning/ transformation using plasmid vectors- GFP gene cloning/ blue and white screening: i. Vector and Insert Ligation, ii. Preparation of competent cells iii. Transformation of E. coli with standard plasmids, iv. Calculation of transformation efficiency 2. PCR amplification 3. Purification of 16S rRNA gene 4. PCR Primer Design 5. Protoplast fusion 6. Activity staining analysis (Zymograms) (NATIVE PAGE) 7.. FTIR analysis of a biomolecule/recombinant molecule (at least five different molecules) 8. Production by recombinant strain and estimation of Biopolymers: i. Gum ii. Polyhydroxyalkanoates (PHB)	2	60

References

1.a) Green Fluorescence Protein cloning (GFP):

- Banerjee S., Kumar J., Apte-Deshpande A. and Padmanabhan S. (2010). A novel prokaryotic vector for identification and selection of recombinants: Direct use of the vector for expression studies in *E. coli.* Microb Cell Fact 9, 30 https://doi.org/10.1186/1475-2859-9-30
- Slama R. A. and Ziada A. S. (2016). Initial stages of construction of a plasmid to study the kinetics of gene expression at a single cell level following uptake of DNA into *Escherichia coli*. Journal of experimental microbiology and immunology. (JEMI). 20: 86-91

1.b) Blue and white screening:

- Julin D.A. (2018) Blue/White Selection. In: Wells R.D., Bond J.S., Klinman J. Masters B.S.S. (eds) Molecular Life Sciences. Springer, New York, NY. https://doi.org/10.1007/978-1-4614-1531-2_94
- Liu J., Chang W., Pan L., Liu X., Su L., Zhangn W., Li Q., and Zheng Y. (2018). An improved method of preparing high efficiency transformation *Escherichia coli* with both plasmids and larger DNA fragments. Indian Journal of Microbiology, 58(4): 448–456. https://doi.org/10.1007/s12088-018-0743-z
- Zhang Y. S. (2016). Blue-white screening liquid can eliminate false positives in blue-white colony screening Genetics and Molecular Research 15 (2): gmr.15027925. http://dx.doi.org/10.4238/gmr.15027925

2 and 3 PCR amplification and purification of 16S rRNA gene:

- Rosselli R., Romoli O., Vitulo, N. Vezzi A., Campanaro S., de Pascale F., Schiavon R., Tiarca M., Poletto F., Concheri G., Valle G. and Squartini A. (2016). Direct 16S rRNA-seq from bacterial communities: a PCR-independent approach to simultaneously assess

microbial diversity and functional activity potential of each taxon. Sci Rep 6:32165 https://doi.org/10.1038/srep32165

- Sabat G., Rose P., Hickey W. J., Harkin J. M. (2000). Selective and sensitive method for PCR amplification of *Escherichia coli* 16S rRNA genes in soil. Appl Environ Microbiol. 66(2):844-849. doi: 10.1128/AEM.66.2.844-849.2000.

4. PCR Primer Design:

Miyazaki K., Sato M. and Tsukuda M. (2017) PCR primer design for 16S rRNAs for experimental horizontal gene transfer test in *Escherichia coli*. Front. Bioeng. Biotechnol. 5:14. doi: 10.3389/fbioe.2017.00014

Ye J., Coulouris G., Zaretskaya I., Zaretskaya I., Cutcutache I., Rozen S. and Madden T. L. (2012). Primer-BLAST: A tool to design target-specific primers for polymerase chain reaction. BMC Bioinformatics 13:134. https://doi.org/10.1186/1471-2105-13-134

5. Protoplast fusion:

- Guon J. L., Gongn D. C., Li Z. J., and Zheng Z. (2013). Construction of yeast strain capable of co-fermenting pentose and hexose by protoplast fusion. Advanced Materials Research. 781–784: 847–851. https://doi.org/10.4028/www.scientific.net/amr.781-784.847
- Shalsh F. J., Ibrahim N. A., Arifullah M. and Hussin A. S. M. (2016). Optimization of the protoplast fusion conditions of *Saccharomyces cerevisiae* and *Pichia stipitis* for improvement of bioethanol production from biomass. Asian Journal of Biological Sciences, 9: 10-18. DOI: 10.3923/ajbs.2016.10.18

6. Activity staining analysis (Zymograms) (NATIVE PAGE):

- Deshmukh A. A., Weist J. L. and Leight J. L. Detection of Protease Activity by Fluorescent Peptide Zymography. J. Vis. Exp. (143), e58938, doi:10.3791/58938 (2019).
- Lanka S. and Latha J. (2015). Purification and characterization of a new cold active lipase, EnL A from *Emericella nidulans* NFCCI 3643. African Journal of Biotechnology. 14:1897-1909
- Wechselberger C., Doppler C. and Bernhard D. (2019). An Inexpensive Staining Alternative for Gelatin Zymography Gels. Methods Protoc. 2: 61. doi:10.3390/mps2030061

FTIR analysis of a **biomolecule/recombinant molecule** (at least five different molecules);

7.a.i) Tannins

Arianna Ricci, Kenneth J. Olejar, Giuseppina P. Parpinello, Paul A. Kilmartin & Andrea Versari (2015) Application of Fourier Transform Infrared (FTIR) Spectroscopy in the Characterization of Tannins, Applied Spectroscopy Reviews, 50:5, 407-442, DOI: 10.1080/05704928.2014.1000461

https://spectrabase.com/spectrum/KPLVhGlArJg

7.a.ii**) Indole acetic acid**

Lobayan RM, Schmit MC, Jubert AH, Vitale A. Theoretical studies and vibrational spectra of 1H-indole-3-acetic acid. Exploratory conformational analysis of dimeric species. J Mol

Model. 2011 Jun;17(6):1381-92. doi: 10.1007/s00894-010-0833-2.

https://spectrabase.com/spectrum/LE3GWjvqQ0

7.b.) **Recombinant molecules**

7.b.i) **Colistin-peptide antibiotic.** (Colistimethanesulfonic Acid injection):

Pacheco T, Bustos RH, González D, Garzón V, García JC, Ramírez D. An Approach to Measuring Colistin Plasma Levels Regarding the Treatment of Multidrug-Resistant Bacterial Infection. Antibiotics (Basel). 2019 Jul 24;8(3):100. doi: 10.3390/antibiotics8030100.

- https://spectrabase.com/spectrum/6sovrQr8OR

7.b.ii) Polymyxin B –peptide antibiotic (Polymyxin B Sulphate Injection): Marwan Y. Hussain, Adnan A. Ali-Nizam and Samir M. Abou-Isba. (2017).

- Antibacterial activities (bacitracin a and polymyxin b) of lyophilized extracts from indigenous *Bacillus subtilis* against *Staphylococcus aureus*. 10(3):205-212. ISSN 1995-6673
- https://spectrabase.com/spectrum/BfcQ8Se5jz

7.b.iii)Ascorbic acid:

Andrei A. Bunaciu, Elena Bacalum, Hassan Y. Aboul-Enein, Gabriela Elena Udristioiu & Şerban Fleschin (2009) FT-IR Spectrophotometric Analysis of Ascorbic Acid and Biotin and their Pharmaceutical Formulations, Analytical Letters, 42:10, 1321-1327, DOI: 10.1080/00032710902954490

https://spectrabase.com/spectrum/47mQ0uyEFIP

I solation and estimation of RNA from bacterial cell

https://medicine.yale.edu/keck/ycga/images/trizolrnaisolation_092107_tcm240-21453.pdf

MB 561 MJ : Nitrogen Metabolism, Respiration and Photosynthesis
Group II Major Elective Theory

Total:2 Credits Workload :-15 hrs. /credit
(Total Workload :-2 credits x 15 hrs.= 30 hrs.in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO 1	To understand biological nitrogen fixation and it's regulation.
CO 2	Gain knowledge of enzymes involved in nitrogen metabolism.
CO 3	Understand anaerobic respiration with respect to chemolithotrphs
CO 4	Differentiate between oxygenic and unoxygenic photosynthesis mechanism.

Credit	Credit Title & Contents	Number of Credits	Number of hours
I	**Nitrogen fixation and amino acid degradation** 1. Biochemistry of biological nitrogen fixation, properties of nitrogenase and its regulation 2. Ammonia assimilation, glutamine synthetase, glutamate dehydrogenase, glutamate synthetase, their properties and regulation 3. Protein turnover and amino acid degradation	1	15
II	**Respiration and photosynthesis:** 1. Respiration: Respiration in chemolithotrophs, sulphur oxidisers, nitrate reducers with respect to electron transport chain and energy generation, Biochemistry of methanogens. 2. Photosynthesis: a. Overview: Plant Photosynthesis. b. Bacterial photosynthesis: photolithotrophs, scope, photosystems c. Bacterial (cyclic, noncylic) photophosphorylation in various groups of phototrophic bacteria (photoautotrophs and photoheterotrophs) d. Electron donors other than water in anoxygenic photosynthetic bacteria	1	15

References

Nitrogen Metabolism

1. Blackstock J. C. (2014). Guide to Biochemistry. United Kingdom: Elsevier Science.
2. Garrett R. H. and Grisham C. M. (2013). Biochemistry. 5th Edition. Brooks/Cole, Publishing Company, California. ISBN-13: 978-1-133-10629-6
3. Madigan M. T., Sattley W. M., Bender, K. S., Stahl D. A., Buckley, D. H. (2018). Brock Biology of Microorganisms. United Kingdom: Pearson.
4. Mandelstam J. and Dawes I. W. and McQuillen K. (1982). Biochemistry of Bacterial Growth. United Kingdom: Wiley.
5. Moat A. G. Foster J. W. and Spector M. P. (2003). (Microbial Physiology. Germany: Wiley.
6. Nelson D. L. and Cox M. M. (2021). Lehninger's Principles of Biochemistry.8th Edition. Mac Millan Worth Pub. Co. New Delhi. ISBN: 9781319228002
7. Satyanarayana U. and Chakrapani U. (2017). Biochemistry - E-Book. India: Elsevier Health Sciences.
8. Voet D. and Voet J. G. (2011). Biochemistry. United Kingdom: Wiley
9. White D., Drummond J. T., Drummond J. and Fuqua C. (2012).The Physiology and Biochemistry of Prokaryotes. United Kingdom: Oxford University Press.

Respiration and Photosynthesis:

1. Doelle H. W. (2014). Bacterial Metabolism. United States: Elsevier Science.

2. Govindjee. (2012). Photosynthesis Volume1. Energy Conversion by Plants and Bacteria. United Kingdom: Elsevier Science.
3. Kim B. H. and Gadd G. M. (2019). Prokaryotic Metabolism and Physiology. United Kingdom: Cambridge University Press.
4. Madigan M. T., Sattley W. M., Bender, K. S., Stahl D. A., Buckley, D. H. (2018). Brock Biology of Microorganisms. United Kingdom: Pearson.
5. Moat A. G. Foster J. W. and Spector M. P. (2003). (Microbial Physiology. Germany
6. Nelson D. L. and Cox M. M. (2005) Lehninger's Principles of Biochemistry, Fourth edition, W. H. Freeman & Co. New York
7. Nelson D. L. and Cox M. M. (2021). Lehninger's Principles of Biochemistry.8th Edition. Mac Millan Worth Pub. Co. New Delhi. ISBN:9781319228002
8. Renger G., Irrgang K.D., Govindjee, Singhal G. S. and Sopory S. K. (2012). Concepts in Photobiology: Photosynthesis and Photomorphogenesis. Netherlands: Springer Netherlands.
9. Woese C. R. (2004). The archaeal concept and the world it lives in: a retrospective. Photosynthesis Research. 80: 361–372.

MB 561 MJP : Practical based on MB 561 MJ Nitrogen Metabolism, Respiration and Photosynthesis

Group II Major Elective Practical

Total:2 Credits Workload :-30 hrs /credit
(Total Workload :-2 credits x 30hrs=60 hrs in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO 1	Isolate Plant growth promoting microorganisms.
CO 2	Know the extraction and estimation of polyphenols, tannins.
CO 3	Isolate and characterize Cyanobacteria.
CO 4	Isolate and characterize lignin/xylan degraders.

Credit Title & Contents	Number of Credits	Number of hours
1. Isolation of IAA producing organism, Detection of Indole acetic acid production by microorganism. 2. Detection of siderophore production by microorganisms 3. Enrichment, Isolation and characterization of nitrogen fixing bacteria. 4. Extraction and estimation of a) polyphenols, b) tannins by Folin Ciocalteu method. 5. Enrichment and isolation of lignin/xylan degraders from Soil. 6. Enrichment, Isolation, and characterization of Sulphur reducing bacteria/Methanogens. 7. Enrichment, Isolation, and characterization of Cyanobacteria. 8. Detection of chlorophyll-a of Cyanobacteria.	2	60

References

1. IsolationofIAAproducingorganism, DetectionofIndoleaceticacidproductionbymicroorganisms: -

- Gang S., Sharma, S., Saraf M., Buck M. and Schumacher J. (2019). Analysis of Indole-3-acetic Acid (IAA) Production in Klebsiella by LC-MS/MS and the Salkowski Method .Bio-protocol. 9(9): e3230. DOI: 10.21769/BioProtoc.3230.
- Mohite B. (2013). Isolation and characterization of indole acetic acid (IAA) producingbacteria from rhizospheric soil and its effect on plant growth. Journal of Soil Science andPlantNutrition, 13(3):638-649.

2. Detection of siderophore production by microorganisms:-

- Ferreira C. M. H., Vilas-Boas Â, Sousa C. A., Soares H. M. V. M. and Soares E. V.(2019) Comparison of five bacterial strains producing siderophores with ability to chelate iron under alkaline conditions. AMB Express. 9(1): 78. doi:10.1186/s13568-019-0796-3.
- SenthilkumarM.,AmaresanN.andSankaranarayananA.(2021).Detectionofsiderophore producingmicroorganisms.In:Plant-MicrobeInteractions.SpringerProtocolsHandbooks.Humana,NewYork,NY.https://doi.org/10.1007/978-1-0716-1080-0_47

3. Enrichment, Isolationandcharacterizationofnitrogenfixingbacteria:-

- Jiménez D. J., Montaña J. S. and Martínez M. M. (2011). Characterization of free nitrogen fixing bacteria of the genus Azotobacter in organic vegetable-grown Colombian soils. Brazilian Journal of Microbiology .42(3): 846-858. https://doi.org/10.1590/S1517-83822011000300003.
- Muangthong A.,Youpensuk S. and Rerkasem B. (2015). Isolation and characterisation of endophytic nitrogen fixing bacteria in sugarcane. Tropical life sciences research, 26(1):41–51.

4. **Extraction and estimation of:-**

4.a.)Polyphenols:

- Aryal S.,Baniya M.K., Danekhu K.,Kunwar P., Gurung R.and Koirala N.(2019).Total phenolic content, flavonoid content and antioxidant potential of wild vegetables from western Nepal. Plants (Basel). 18(4): 96. doi: 10.3390/plants8040096.
- PouraliA., Afrouziyeh M. and Moghaddaszadehahrabi S. 2014. Extraction of Phenolic compounds and quantification of the total phenol of grape pomace. European Journal of Experimental Biology. 4(1):174-176.

4. b) Tannins by Folin Danis method:

- Chandran K. and Indria G. (2016). Quantitative estimation of total phenolic, flavonoids, tannin and chlorophyll content of leaves of StrobilanthesKunthiana (Neelakurinji). Journal of Medicinal Plants Studies, 4(4): 282-286.
- Rhazi N., Hannache H., Oumam M., Sesbou A., Charrier B., Pizzi A., Charrier-El Bouhtoury F. (2019). Green extraction process of tannins obtained from Moroccan Acacia mollissima barks by microwave: Modeling and optimization of the process using the response surface methodology RSM. Arabian Journal of Chemistry. 12(8): 2668- 2684. https://doi.org/10.1016/j.arabjc.2015.04.032.

5. Enrichment and isolation of lignin/xylan degraders from Soil:- 5.a) Lignin degraders:

- DeAngelis K. M., Allgaier M., Chavarria Y., Fortney J. L., Hugenholtz P., Simmons B., Sublette K., Silver W. L. and Hazen T. C.. (2011). Characterization of trapped lignin-degrading microbes in tropical forest soil. PLoS ONE 6(4): e19306.

https://doi.org/10.1371/journal.pone.0019306

- Yang, C.-X., Wang, T., Gao, L.-N., Yin, H.-J. and Lü, X. (2017), Isolation, identification and characterization of lignin-degrading bacteria from Qinling, China. J Appl Microbiol, 123: 1447-1460. https://doi.org/10.1111/jam.13562 5. b) Xylan degraders:
- Kambale R. and Jadhav A. (2012). Isolation, purification, and characterization of xylanase produced by a new species of bacillus in solid state fermentation. International J of Microbiology.volume- 2012. Article ID 683193 doi: 10.1155/2012/683193
- Zerva I., Remmas N. and Ntougias S. (2019). Diversity and biotechnological potential of xylan-degrading microorganisms from orange juice processing waste. Water.11(2): 274. https://doi.org/10.3390/w11020274

6. Enrichment, Isolation and characterization of :- 6. a) Sulphur reducing bacteria:

- Sass H. and Cypionka H. (2004). Isolation of sulfate-reducing bacteria from the terrestrial deep subsurface and description of Desulfovibrio cavernae sp. nov. Systematic and Applied Microbiology. 27(5): 541-548. https://doi.org/10.1078/0723202041748181.
- Simankova M. V., Kotsyurbenko O. R., Lueders T., Nozhevnikova A. N., Wagner B.,
  Conrad R. and Friedrich M. W. (2003). Isolation and characterization of new strains of methanogens from cold terrestrial habitats. Systematic and Applied Microbiology. 26(2): 312-318. https://doi.org/10.1078/072320203322346173.

6. b)Methanogens:

- Kumar S., Dagar S. S. and Puniya A. K. (2012). Isolation and characterization of methanogens from rumen of Murrah buffalo. Ann Microbiol 62, 345–350 https://doi.org/10.1007/s13213-011-0268-8
- Simankova M. V., Kotsyurbenko O. R., Lueders T., Nozhevnikova A. N., Wagner B., Conrad R. and Friedrich M. W. (2003). Isolation and characterization of new strains of methanogens from cold terrestrial habitats. Systematic and Applied Microbiology. 26(2): 312-318. https://doi.org/10.1078/072320203322346173.

7. Enrichment, Isolation and characterization of Cyanobacteria:-

- Pramanik, A., Sundararaman, M., Das, S., Ghosh, U. and Mukherjee, J. (2011). Isolation and characterization of cyanobacteria possessing antimicrobial activity from the Sundarbans, the world's largest tidal mangrove forest1. Journal of Phycology, 47: 731- 743. https://doi.org/10.1111/j.1529-8817.2011.01017.x
- Urmeneta, J., Navarrete, A., Huete, J. and Guerrero R. (2003). Isolation and characterization of cyanobacteria from microbial mats of the Ebro Delta, Spain. CurrMicrobiol 46, 0199–0204 https://doi.org/10.1007/s00284-002-3856-9

8. Detection of chlorophyll-a activity of Cyanobacteria:-

- Johan F., Jafri M. Z., Lim H. S. and Wan Maznah W. O. (2014). "Laboratory measurement: Chlorophyll-a concentration measurement with acetone method using spectrophotometer." IEEE International Conference on Industrial Engineering and Engineering Management. 744-748, doi: 10.1109/IEEM.2014.7058737.

Zavřel T, Sinetova M and Červený J. 2015. Measurement of Chlorophyll a and Carotenoids Concentration in Cyanobacteria. bio-protocol, 5. www.bioprotocol.org/e1467

MB 562 MJ: Molecular Biophysics

Group III Major Elective Theory

Total:2 Credits Workload:-15 hrs/credit

(Total Workload :-2 credits x 15 hrs= 30 hrs in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO 1	Understand proper handling of various instruments.
CO 2	Know the importance of the use of X-ray crystallography in purification of proteins.
CO 3	Understand application of Radioisotopes in Biology.
CO 4	To know the usefulness/Utility of Confocal Microscopy.

Credit	Credit Title & Contents	Number of Credits	Number of hours
I	**Biophysical Techniques** 1. NMR spectroscopy: Basic Principles of NMR, Chemical shift, Intensity, Line width, Relaxation parameters, Spin coupling, Nuclear Over hauser Effect Spectroscopy, Correlation Spectroscopy, Approach to structure determination by 2D-NMR 2. X-ray crystallography: Purification of proteins, Crystallization of proteins, Instrumentation, acquisition of the diffraction pattern, basic principles of X-ray diffraction, Crystal Structures (Bravais Lattices), Crystal planes and Miller Indices, Fourier Transform and Inverse Fourier, Direct Lattice and Reciprocal lattice, Ewald sphere, Electron density Maps, Phase determination	1	15
II	**Radioisotopes in Biology and Confocal Microscopy** 1. Radioisotopes in Biology: Principles and applications of radiotracers in medicine, agriculture, industry, and fundamental research. Radiation and Radioactive isotopes: Types, Quantities, and units of estimation, the half-life of isotopes. Detection and measurement of radioactivity- Autoradiography, Liquid scintillation counting. Effect of Radiation on a biological system 2. Confocal Microscopy: scanning optical microscope, confocal principle, resolution and point spread function, light source: gas lasers & solid-state, primary beam splitter; beam scanning, pinhole, and signal channel configurations, detectors; pixels and voxels; contrast, spatial sampling: temporal sampling: signal-to-noise ratio, multichannel images	1	15

References

Suggested References: **MBET-427: Molecular Biophysics**

Instrumentation and Molecular Biophysics

1. Boyer R. F. (2000). Modern experimental biochemistry. India: Pearson Education.
2. Chakravarty R., Goel S. and Cai W. (2014). Nanobody: the "magic bullet" for molecular imaging? Theranostics. 4(4): 386-398. doi:10.7150/thno.8006
3. Dennison C. (2013). A guide to protein isolation. Netherlands: Springer Netherlands.
4. Desiderio D. M., Kraj A. and Nibbering N. M. (2009). Mass spectrometry: instrumentation, interpretation and applications. United Kingdom: Wiley.
5. Feldheim D. L. and Foss C. A., Jr. (Editors). (2002) Metal nanoparticles synthesis and characterization and applications. Taylor & Francis
6. Hofmann A., Walker J. M., Wilson K. and Clokie S. (2018). Wilson and Walker's Principles and techniques of biochemistry and molecular biology. United Kingdom: Cambridge University Press.
7. Mirkin C. A. and Niemeyer C. M. (2006). Nanobiotechnology: Concepts, Applications and Perspectives. Germany: Wiley.
8. Mirkin C. A. and Niemeyer C. M. (2007). Nanobiotechnology II: More Concepts and Applications. Germany: Wiley.
9. Mount D. W. (2005). Bioinformatics: sequence and genome analysis. India: CBS Publishers & Distributors.
10. Narayanan P. (2007). Essentials of biophysics. India: New Age International.
11. Nölting B. (2013). Methods in modern biophysics. Germany: Springer Berlin Heidelberg.
12. Pattabhi V. and Gautham N. (2002). Biophysics. India: Springer Netherlands.
13. Rai M. and Duran N. (2011). Metal nanoparticles in microbiology. Germany: Springer Berlin Heidelberg.
14. Rutherford T. (2019). Principles of analytical biochemistry. Alexis Press LLC. New York.
15. Segel I. H. (2010). Biochemical calculations. 2nd Edition. India: Wiley India Pvt.Ltd
16. Sohier J. S., Laurent C., Chevigné A., Pardon E., Srinivasan V., Wernery U., Lassaux P., Steyaert J. and Galleni M. (2013). Allosteric inhibition of VIM metallo-β- lactamases by a camelid nanobody. Biochem J. 450(3): 477-86. doi: 10.1042/BJ20121305.
17. Webster D. M. (2000). Protein Structure Prediction: Methods and Protocols. Ukraine: Humana Press.

MB 562 MJP : Molecular Biophysics

Group III Major Elective Practical based on MB 562 MJ

Total:2 Credits Workload:-30 hrs/credit

(Total Workload :-2 credits x 30 hrs= 60 hrs in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO 1	Understand the Experimentation and interpretation of data using Radioisotopes.
CO 2	To solve virtual lab problem-based exercises.
CO 3	To know the Utility of various instruments.
CO 4	Learn the use of instruments in biophysical techniques.

Credit	Credit Title & Contents	Number of Credits	Number of hours
I	1. Virtual lab problem-based exercise to understand the instrumentation, experimentation and interpretation of data obtained using Radioisotopes in experiment 2. Virtual lab problem-based exercise to understand the instrumentation, experimentation and interpretation of Bravais Lattices 3. Virtual lab problem-based exercise to understand the instrumentation, experimentation and interpretation of data obtained using NMR	1	30
II	1. Virtual lab problem-based exercise to understand the instrumentation, experimentation and interpretation of data obtained using X-ray diffraction pattern 2. Virtual lab problem-based exercise to understand the instrumentation, experimentation and interpretation of data obtained using, X-Ray crystallography 3. Virtual lab problem-based exercise to understand the instrumentation, experimentation and interpretation of data obtained using Confocal Microscope	1	30

References

Suggested References: **MBET-427: Molecular Biophysics**

1) Use of reference, use of reference management tools (e.g. Zotero).
https://aut.ac.nz.libguides.com/managingreferences
https://aut.ac.nz.libguides.com/c.php?g=843515&p=6028899
2) Virtual lab exercise to understand the instrumentation, experimentation and interpretation of data obtained using HPLC, FACS, FTIR, GC-MS, NMR, X-Ray crystallography MALDI TOF, SEM, TEM, AFM, Confocal Microscope (representative websites)
Virtual proteomics laboratory IIT Bombay: http://pe-iitb.vlabs.ac.in/

MB 563 MJ: Bioinformatics

Group IV Major Elective Theory

Total:2 Credits Workload:-15 hrs/credit

(Total Workload :-2 credits x 15 hrs= 30 hrs in semester)

Course outcomes COs	
After studying the course learners will be able to	
CO 1	Understand the importance of bioinformatics.
CO 2	Use Methods of sequencing and various databases for microorganisms.
CO 3	Learn how to submit the sequences to databases.
CO 4	Understand the use of tools and softwares in bioinformatics.

Credit	Credit Title & Contents	Number of Credits	Number of hours
I	1).Introduction to Bioinformatics 2).Overview of Bioinformatics resources on the web - NCBI/EBI/EXPASY etc. 3).Nature of biological data and formats 4).Literature databases (searching & downloading) 5).Nucleic acid sequence databases – GenBank, EMBL, DDBJ; RefSeq, dbSTS, dbEST 6).Protein sequence databases UniProtKB UniRef, UniParc, Proteomes, NextProt	1	15
II	7).RNA sequence databases miRBase, IncRNAdb,MIT/ICBP siRNA database 8).Nucleic acid and Protein sequence analysis- pairwise sequence alignment, multiple sequence alignment 9).Database Searches – Introduction to BLAST and FASTA 10).Structure databases – PDB, NDB 11).Molecular Phylogeny Concept & overview Distance-based methods: UPGMA & NJ Character-based methods: Maximum Parsimony	1	15

MB 563 MJP: Bioinformatics

Group IV Major Elective Practical based on MB 563 MJ

Total:2 Credits Workload:-30 hrs/credit

(Total Workload :-2 credits x 30 hrs= 60 hrs in semester)

Course Outcomes (COs)	
After studying this course learners will be able to	
CO1	Understand the gene sequencing process.
CO2	Explain the process of amplification and purification of 16S rRNA.
CO3	Carry out Sequence matching and BLAST Analysis.
CO4	To draw phylogenetic tree.

Credit Title & Contents	Number of Credits	Number of hours
-16S rRNA gene sequencing analysis of bacteria: -Isolation, purity checking using A260/A280 ratio and Agarose gel - electrophoresis of isolated chromosomal DNA of bacteria -PCR amplification and purification of 16S rRNA gene - Demonstration of the following steps, if not possible to perform in your lab: PCR product Sequencing using automated sequencer - Sequence matching by BLAST analysis. -Drawing phylogenetic tree using related sequences (Using standard software like Phylip, Mega etc.	2	60

Suggested References: MBEP428-Bioinformatics Group III Major Elective Practical

1. Janda J. M. and Abbott S. L. (2007).16S rRNA gene sequencing for bacterial identification in the diagnostic laboratory: pluses, perils, and pitfalls. J Clin Microbiol.45(9): 2761-2764. doi: 10.1128/JCM.01228-07. Epub 2007 Jul 11. PMID: 17626177; PMCID: PMC2045242.
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9. Following linux software tools can be used for practicals

Bioconductor	Analysis and comprehension of high-throughput genomic data
Biopython	Tools for biological computation written in Python
BioPerl	Perl tools for computational molecular biology
InterMine	Integrate biological data sources
UGENE	Set of integrated bioinformatics software
IGV	High-performance visualization genome browser tool
BioJava	Provides Java tools for processing biological data
GROMACS	Versatile package to perform molecular dynamics
Taverna Workbench	For designing and executing bioinformatics workflows
EMBOSS	The European Molecular Biology Open Software Suite

Clustal Omega	Multiple sequence alignment program
BLAST	Algorithm for comparing primary biological sequence information
bedtools	Powerful toolset for genome arithmetic
geWorkbench	Software platform for integrated genomic data analysis
Bioclipse	Rich-client platform chemistry and biology workbench