**Title of the Program:**

**M.Sc. Microbiology as per NEP 2020**

The Poona Gujarati Kelavani Mandal's

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

## Syllabus for

## M.Sc. Microbiology Part –I

## NEP 2020

## 2023 Pattern

## Affiliated to Savitribai Phule Pune University

## To be implemented from Academic Year

## 2024-2025

## 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 goodsand 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:**

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

**Total credits:**

A full masters' degree course in science would be of 88 credits. One credit course of theory will be of one clock hour per week, running for 15 weeks and one credit for practical course will consist of 30 clock hours of laboratory exercises. One credit is equivalent to one hour of teaching (theory) or two hours of practical work/field work per week. There shall be four semesters and credits are distributed over 4semesters. There will be 2 core compulsory theory courses (4 credits each), one core compulsory theory course (2 credits) and one core compulsory Practical course (4 credits). In addition to this, choice based optional paper means elective courses are offered consisting of 2 theory credits courses and allied 2 practical credit courses. There are also Research Methodology (RM), Internship/ On the Job training (O/T) and Research Project credits assigned to a particular semester.

## 5. Credit Framework for Post Graduate (PG):

### Credit Framework for Post Graduate (PG):

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

## 6. Eligibility for Admission:

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

## 7. Medium of Instruction: English

## 8. Award of Credits:

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

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

## 9. Course structure & assessment of Credits: M. Sc. First year Microbiology Semester I

MB: Microbiology; MJ-TH: Major Theory; MJ-PR: Major Practical; RM-TH: Research Methodology Theory; RM-PR- Research Methodology Practical

| Components Study | Course Code | | Course Name | Credit | Assessment | | |
|---|---|---|---|---|---|---|---|
| | | | | | CIA | SEE | Total |
| Core Compulsory Theory Papers | MB 501 MJ - TH | | Microbial Systematics | 4 | 40 | 60 | 100 |
| | MB 502 MJ - TH | | Biochemistry, Cell, and Developmental Biology | 4 | 40 | 60 | 100 |
| | MB 503 MJ - TH | | Basic Quantitative Biology | 2 | 20 | 30 | 50 |
| Core Compulsory Practical paper | MB 504 MJ - PR | | Practicals based on MB 501 MJ -TH Microbial Systematic, MB 502 MJ - TH Biochemistry, Cell and Developmental Biology, and MB 503 MJ -TH Basic Quantitative Biology | 4 | 40 | 60 | 100 |
| Research Methodology Theory | MB 531 RM -TH | | Research Methodology | 2 | 20 | 30 | 50 |
| Research Methodology Practical | MB 531 RM - PR | | Research Methodology | 2 | 20 | 30 | 50 |
| Choice Based Optional Papers Elective/ Departmental Course Any one group | Group I | MB 510 MJ - TH | Microbial Extremophiles | 2 | 20 | 30 | 50 |
| | | MB 510 MJ - PR | Practicals Based on MB 510 MJ - TH Microbial Extremophiles | 2 | 20 | 30 | 50 |
| | **OR** | | | | | | |
| | Group II | MB 511 MJ - TH | Microbial communication,Membrane transport and signal transduction | 2 | 20 | 30 | 50 |
| | | MB 511 MJ - PR | Practicals Based on MB 511 MJ-TH Microbial communication, Membrane transport and signal transduction | 2 | 20 | 30 | 50 |
| | **OR** | | | | | | |
| | | MB 512 MJ - TH | Advanced Quantitative Biology | 2 | 20 | 30 | 50 |
| | Group III | MB 512 MJ - PR | Practicals based on MB 512 MJ -TH Advanced Quantitative Biology | 2 | 20 | 30 | 50 |
| | **OR** | | | | | | |
| | Group IV | MB 513 MJ - TH | Experimental Design and Quantitative approaches for Biologist | 2 | 20 | 30 | 50 |
| | | MB 513 MJ - PR | Practicals based on MB 513 MJ-TH Experimental Design and Quantitative approaches for Biologist | 2 | 20 | 30 | 50 |

## Course structure & assessment of Credits: - M. Sc. First year Microbiology Semester II

MB: Microbiology; MJ- TH: Major Theory; MJ-PR: Major Practical; OJT-Internship/ On job training

| Course Type | Course Code | | Course Name | Credit | Assessment | | |
|---|---|---|---|---|---|---|---|
| | | | | | CIA | SEE | Total |
| Core Compulsory Theory Papers | MB 551 MJ -TH | | Molecular Biology I | 4 | 40 | 60 | 100 |
| | MB 552 MJ -TH | | Enzymology, Bioenergetics and Metabolism | 4 | 40 | 60 | 100 |
| | MB 553 MJ -TH | | Laboratory Techniques and Instrumentation | 2 | 20 | 30 | 50 |
| Core Compulsory Practical paper | MB 554 MJ -PR | | Practicals based on MB 551 MJ-TH Molecular Biology I, MB 552 MJ-TH Enzymology, Bioenergetics and Metabolism and MB 553 MJ-TH Laboratory Techniques and Instrumentation | 4 | 40 | 60 | 100 |
| Internship/ On job training | MB 581 OJT | | Internship / On job training | 4 | 40 | 60 | 100 |
| Choice Based Optional Papers Elective/Departmental Course Any one group | Group I | MB 560 MJ -TH | Molecular Biology tools and applications | 2 | 20 | 30 | 50 |
| | | MB 560 MJ -PR | Practical based on MB 560 MJ-TH Molecular Biology tools and applications | 2 | 20 | 30 | 50 |
| | **OR** | | | | | | |
| | Group II | MB 561 MJ -TH | Nitrogen Metabolism, Respiration and Photosynthesis | 2 | 20 | 30 | 50 |
| | | MB 561 MJ -PR | Practicals based on MB 561 MJ-TH Nitrogen Metabolism, Respiration and Photosynthesis | 2 | 20 | 30 | 50 |
| | **OR** | | | | | | |
| | Group III | MB 562 MJ -TH | Molecular Biophysics | 2 | 20 | 30 | 50 |
| | | MB 562 MJ -PR | Practicals based on MB 562 MJ-TH Molecular Biophysics | 2 | 20 | 30 | 50 |
| | **OR** | | | | | | |
| | Group IV | MB 563 MJ -TH | Bioinformatics | 2 | 20 | 30 | 50 |
| | | MB 563 MJ -PR | Practicals based on MB 563 MJ-TH Bioinformatics | 2 | 20 | 30 | 50 |

## 10. Evaluation Pattern:

### Examination Rules

A student cannot appear for semester end examination unless he/she has maintained 75% attendance during the teaching period of that course. If a student fails to maintain attendance up to 75%, at the time of filling of examination forms, an undertaking from the student should be taken stating that he/she will be allowed to appear for examination subject to fulfilment of required attendance criteria during the remaining period of teaching of the course.

Each course carrying 100 marks shall be evaluated with Continuous Internal Assessment (CIA) and Semester End Examination (SEE). Continuous Internal Assessment (CIA) shall be of 40 marks (40%) while the Semester End Examination (SEE) shall be of 60 marks (60%). To pass in a course, a student has to secure minimum 40 marks (40%) provided that he should secure minimum 24 marks (40%) in Semester End Examination and 16 marks (40%) in Continuous Internal Assessment.

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

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

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

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

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

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

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

**11. ATKT Rules:**

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

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

**12. Completion of Degree Course:**

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

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

**Table 1: Percentage to Grades and Grade Points**

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

Credit Point =(Credit x Grade point)

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

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

13. **Performance Indices**:

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

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

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

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

## 14. Result

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

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

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

| Program Specific Outcomes (PSOs) for M. Sc. Microbiology | |
|---|---|
| **PSO** | **Program Specific Outcomes (PSOs)** |
| | **Upon completion of this programme the student will be able to** |
| **PSO1** | **Academic competence:** |
| | **i)** Describe microbial processes that can be used for the development of biochemical and immunological tools to improve the quality of human life. |
| | **ii)** Study the cytology, biochemistry, growth as well as application of environmentally and industrially important microbes with a specific emphasis on improving environmental sustainability and human health. |
| | **iii)** Describe and understand the concepts of role of microorganisms in geochemical processes like leaching of metals and bioremediation methods |
| **PSO2** | **Personal and Professional competence:** |
| | **i)** Apply tools of molecular taxonomy and bioinformatics to the study of diverse microbial groups. |
| | **ii)** Evaluate industrially important microbial products in terms of their purity, safety and ethically acceptable application for the benefit of mankind. |
| | **iii)** Combine public presentation skills of effective articulation and non-verbal communication with a sound understanding of microbial science to effectively communicate ideas |
| **PSO3** | **Research competence:** |
| | **i)** Validate scientific hypothesis and editorialize experimental scientific data by using statistical tools applicable to biological sciences. |
| | **ii)** Integrate principles of biology and physical sciences to standardize detection andquantification methods using sophisticated techniques. |
| **PSO4** | **Entrepreneurial and Social Competence:** |
| | **i)** Employ skill sets related to Quality assurance and testing of pharmaceutically important products in accordance with internationally accepted standards. |
| | **ii)** Evaluate the importance of new groups of consumer goods such as prebiotics, probiotics and nutraceuticals. |
| | **iii)** Apply the concepts of microbial interactions in basic and advanced treatment of wastewater treatment processes. |

**M. Sc. Microbiology Part I Semester I**

**MB 501 MJ - TH: 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**<br>1. Species concept in prokaryotes and eukaryotes.<br>2. Five-Kingdom classification system and Three-Domain classification system.<br>3. Overview of fungal systematics and Differentiating characters among different Classes of fungi.<br>4. Determinative Bacteriology (Phenetic Approach) and Systematic Bacteriology (Phylogenetic Approach).<br>5. Polyphasic Approach.<br>6. Molecular clocks, phylogeny and molecular distances. | 1 | 15 |
| **II** | **Microbial Diversity**<br>1. Facets of microbial diversity: morphological, structural, metabolic, ecological, behavioral and evolutionary.<br>2. Species divergence and measurement of microbial diversity.<br>3. Measures and indices of diversity; alpha, beta and gamma diversity. | 1 | 15 |
| **III** | **Exploration of Uncultured Microbial Diversity**<br>1. Concept of unculturable bacterial diversity.<br>2. Strategies for culture of unculturable bacteria.<br>3. Culture independent molecular methods for identifying unculturable bacteria (PCR, RFLP, ARDRA, DGGE, TGGE, | 1 | 15 |

| | | | |
|---|---|---|---|
| | RAPD, Microarray, FISH, RISA).<br><br>4. Methods of extracting total bacterial DNA from a habitat and metagenome analysis. | | |
| **IV** | **Evolution:**<br>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.<br>2. Socio-biology, kin selection, evolutionary stability of cooperation, sociality and multi-cellularity in microorganisms, Game theory. Co-evolutionary strategies, host parasite co-evolution.<br>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-TH : 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** | |
| CO 1 | Students learn about structural features of amino acids and proteins and their functions. |
| CO 2 | Students get introduced with biochemistry and molecular biology technique. |
| CO 3 | Students get introduced to developmental biology in that hox code, mechanism of gastrulation, pattern formation in body axis |
| CO 4 | Students get introduced with ultra structure and organization of eukaryotic cell, protein transport and cell cycle. |

| Credit | Credit Title and Contents | Number of Credits | Number of hours |
|---|---|---|---|
| **I** | **Protein Chemistry**<br>1. Structural features of amino acids, classification of amino acids, Amino acids as buffers.<br>2. Henderson Hasselbalch equation and its role in buffer formulation. Peptide linkage, partial double bond nature of peptide bond.<br>3. Determination of primary structure of polypeptide (N- terminal, C-terminal determination, method of sequencing of peptides). | 1 | 15 |
| | 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.<br>6. Secondary, Super-secondary, Motif & Domain.<br>7. Tertiary and Quaternary structures of proteins, (Myoglobin & hemoglobin). | | |
| **II** | 1. **Nucleic acid chemistry:**<br>Structure of bases, nucleosides, nucleotides, 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.<br>**2. Carbohydrate Chemistry**<br>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.<br>3. **Lipid Chemistry**<br>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. | 1 | 15 |
| **III** | **Developmental Biology**<br>1. Introduction to developmental biology. Different model systems used to study developmental biology.<br>2. Conserved nature of development, Concepts of commitment, determination and differentiation.<br>3. Morphogen gradients in developmental regulation, Hox code, MPF.<br>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. | 1 | 15 |
| | 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. | | |

| | | | |
|---|---|---|---|
| **IV** | 1. Structural organization and function of Endoplasmic Reticulum, Golgi apparatus, Nucleus, Mitochondrion, chloroplast, Lysosomes, peroxisomes; Cytoskeleton and function of Molecular motors.<br>2. Protein trafficking among various cellular compartments (by secretory and cytosolic pathway: targeting to secretory vesicles, cell membrane, lysosomes, nucleus, mitochondria and peroxisomes).<br>3. Events in cell cycle, Regulation of cell cycle. Apoptosis. | 1 | 15 |

**References**


**Credit I Protein Chemistry and II Nucleic acid chemistry , Carbohydrate Chemistry ,Lipid Chemistry**

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.8$^{th}$Edition. 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 –TH: 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 and Contents** | **Number Credits** | **Number of hours** |
|---|---|---|---|
| **I** | **Descriptive Statistics**<br>1. Fundamental concepts – Basic terminologies, sample statistics and population parameter, variable and its types (qualitative and quantitative, discrete and continuous) measurement scales (nominal, ordinal, interval and ratio), data (types and sources).<br>2. Collection and organization of data, tabulation (frequency distribution table and its components), diagrammatic and graphical representation (Bar diagram and its types, pie chart, histogram, frequency polygon and ogive curves, survival curves).<br>3. Measures of central tendency –arithmetic mean, median, mode, geometric mean.<br>4. Measures of dispersion and their coefficients – Standard deviation and variance.<br>5. Correlation, scatter plots, Pearson's correlation coefficient, simple linear regression (no significance testing). | 1 | 15 |
| **II** | **1. Probability**<br>Probability, basic concept (sample space, experiment, | 1 | 15 |

| | | | |
|---|---|---|---|
| | event, outcome).<br>i. Permutation and combination, addition and multiplication rule.<br>ii. Probability distribution and its types.<br>iii. Binomial, normal and Poisson distribution.<br>**2. Inferential Statistics:**<br>i. Central Limit Theorem, Distribution of sample mean, standard error and confidence interval.<br>ii. Test of significance:<br>a. Overview, Inference, concepts of null hypothesis, alternate hypothesis, test statistic, significance level, p-value, type I and type II errors, one tailed and two tailed tests, degrees of freedom.<br>b. Types: Parametric and non-parametric (comparative account).<br>Parametric tests (Mean and proportion)): t-test and z-test (*Biological examples/data should be used to solve the problem* ). | | |

**References**

1. Bailey N. T. J. (1995). Statistical methods in Biology. 3rd Edition. Cambridge University Press.

2. Brown D. and Rothery P. (1993). Models in Biology: Mathematics, Statistics and Computing. John Wiley &Sons, USA. ISBN: 9780471933229.

3. Daniel W. W. and Cross C. L. (2007), Biostatistics A foundation for Analysis in the Health Sciences. Wiley. ISBN: 978-1-119-49657-1.

4. Gupta S. P. (2021). Statistical Methods. 46th Edition. Sultan Chand & Sons Publisher, New Delhi. ISBN: 978-93-5161-176-9.

5. Khan I. A. and Khanum A. (2004). Fundamentals of Biostatistics. 3rd Edition. Ukaaz Publications, Hyderabad. ISBN: 8190044109, 9788190044103.

6. Lindgren B. W. (1976). Statistical Theory. 3rd Edition Macmillan Publishing Co. Inc. ISBN 13: 9780023708305.

7. McNeil B. and Harvey L. (2008). Practical Fermentation Technology. Wiley InterScience. ISBN 978-0-470-01434-9.

8. Montgomery D. C. (2019). Design and Analysis of Experiments. 10th Edition. Wiley. ISBN: 978-1-119-49244-3.

9. Newman S. C. (1952). Biostatistical Methods in Epidemiology. John Wiley & Sons.

10. Petrie A. and Sabin C. (2019). Medical Statistics at a Glance. 5nd Edition. Wiley.

11. Rosner B. (2015). Fundamentals of Biostatistics. 8th Edition. Publisher: Cengage Learning. ISBN: 1305465512, 9781305465510.

12. Sundar Rao P. S. S. and Richard J. (2012). Introduction to Biostatistics and Research Methods. 5th Edition. PHI Learning Private Limited, New Delhi.

**MB 504 MJ -PR: Practicals based on MB 501 MJ -TH Microbial Systematic, MB 502 MJ -TH Biochemistry, Cell and Developmental Biology, and MB 503 MJ -TH Basic Quantitative Biology**

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.Use methods for extraction of microbial bio molecules 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.<br>2. Standardization of laboratory procedures, calibration and validation instruments, preparing /designing SOP for the same, maintenance of instruments.<br>3. Buffer: Determination of pKa of a monoprotic weak organic acid by titration and graph method.<br>4. Preparation of buffer using $KH_2PO_4$ and $K_2HPO_4$.<br>5. Preparation of buffer using acetic acid and sodium acetate.<br>6. Preparation of buffer using $K_2HPO_4$ and $H_3PO_4$.<br>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). | 4 | 120 |
| 8. Statistical analysis of data – Students t test.<br>9. Enrichment, Isolation and identification of the following from natural samples: Gram-negative bacteria.<br>10. Enrichment, Isolation and identification of the following from natural samples: Gram positive bacteria.<br>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)<br><br>11. Studying the stages of mitosis in the growing tip of onion root cells.<br>12. Studying and observing polyploidy induced by colchicin treatment on Onion root tip.<br>13. Demonstration of mounting embryo fruit fly at various developmental stages on permanent slides.<br>14. Extraction of Protein using TCA from bacterial culture.<br>15. Extraction of Exo-polysaccharide from Microbial culture using organic solvent. (May use ethanol method).<br>16. Spectrophotometry: estimation of above extracted protein sample: Bradford and UV-Spectrophotometry.<br>17. Spectrophotometry: estimation of above extracted EPS sample: Phenol Sulphuric Acid method.<br>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**

1. Fuscaldo A. (2012). Laboratory Safety Theory and Practice. United Kingdom: Elsevier Science.
2. 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.
3. Plummer M. and Plummer D.T. (2001). Introduction to practical biochemistry. 3rd Edition, Tata McGraw- Hill Edition.
4. United States Environmental protection agency (EPA), EPA QA/G-6. 2007. Guidance for preparing SOP. 1-6.
5. World Health Organization Staff, World Health Organization. Laboratory Biosafety Manual, 3/Ed. (2006). India: AITBS Publishers.
6. https://www.labmanager.com/lab-health-and-safety/science-laboratory-safety-rules-guidelines-5727.

**Buffer:**

1. Jayaraman J. (2004). Laboratory Manual in Biochemistry. India: New Age International (P).
2. Plummer M. and Plummer D.T. (2001). Introduction to practical biochemistry. 3rd Edition, Tata McGraw- Hill Edition.
3. Sadasivam S. and Manickam A. (2008). Biochemical methods. 3rd Edition, New Age International Publishers, India.
4. Segel I. H. (2010). Biochemical Calculations, 2nd Edn. India: Wiley India Pvt. Ltd.

**Computer applications**:

5. Conner N. and MacDonald M. (2013). Office 2013: The Missing Manual. United States: O'Reilly Media.

6. McFedries P. (2019). Microsoft Excel 2019 Formulas and Functions. PearsonEducation.

https://www.britannica.com/technology/spreadsheet.

**Statistical analysis of data** –

1. Boslaugh S. (2012). Statistics in a Nutshell. Germany: O'Reilly Media Incorporated.

2. McFedries P. (2019). Microsoft Excel 2019 Formulas and Functions. Pearson Education

3.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**

1. Mohammad B. T., Al Daghistani H. I., Jaouani A., Abdel-Latif S. and Kennes C. (2017).

2. 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.

3. 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.

1. 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.

**2. 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.

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

**Extraction of Protein and Exo-polysaccharide**

1. 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**:

1. Jayaraman J. (2004). Laboratory Manual in Biochemistry. India: New Age International (P) Limited Publishers.

2.Plummer M. and Plummer D.T. (2001). Introduction to practical biochemistry. 3rd Edition, Tata McGraw- Hill Edition.

3.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.

4.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**

1. Bansal M. and Srinivasan N. (2013). Biomolecular Forms and Functions: A Celebration of 50 Years of the Ramachandran Map. Singapore: World Scientific.

2. Bourne P. E. (2011). Structural Bioinformatics. Germany: Wiley.

3. Ramachandran G.N., Ramakrishnan C. and Sasisekharan V. (1963). Stereochemistry of Polypeptide Chain Configurations. J. Mol. Biol. 7: 95-99.

4. Pazos F. and Chagoyen M. (2014). Practical Protein Bioinformatics. Germany: Springer International Publishing.

## MB 531 RM-TH Research Methodology
## 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 research terminology |
| CO 2 | Describe quantitative, qualitative and mixed methods approaches to research |
| CO 3 | Identify the components of a literature review process |
| CO 4 | Analyze and interpret the research |
| CO 5 | Apply ethical principles of research in preparation of scientific documents |

| Credit | Credit Title and Contents | Number of credits | Number of hours |
|---|---|---|---|
| I | 1. History of research.<br>2. Research concept: Definition, Characteristics, Objectives, Utility.<br>3. Types of Research: Descriptive vs. Analytical Research; Applied vs. Fundamental Research; Quantitative vs. Qualitative Research; Conceptual vs. Empirical Research<br>4. Problem Identification & Formulation: Formulating the research problem, Defining the research problem, Origin of the research problem.<br>5. Literature Review: Purpose of the literature review, Types of information and sources, Primary and secondary sources.<br>6. Research Objectives.<br>7. Research design: Types of research design (descriptive research design, correlational research design, experimental research design, explanatory research design).<br>8. Research methods: Quantitative research, Qualitative research, Experimental research, and mixed methods approaches, Data Analysis and Interpretation, Sample collection and processing techniques (Water, soil, air and medical).<br>9. Citation: Methods, Bibliography, citation rules.<br>10. Current trends in Research: Mono-disciplinary Research, Trans- disciplinary Research, Inter-disciplinary Research, Threats and Challenges to Good Research. | 1 | 15 |

| | | | |
|---|---|---|---|
| **II** | 1. Data Presentation: Presentation skills, formal scientific presentation skills; Preparing power point presentation, Presenting the work, Scientific poster preparation.<br>2. Research report writing: Purpose of the writing, Types and Formats of scientific reports, scientific writing skills, Significance of communicating science, ethical issues, Copy rights and plagiarism, Components of a research paper<br>3. Preparation of Project Proposal – Time frame and work plan – Budget and Justification. | 1 | 15 |

**References**

1. Research in Medical and Biological Sciences: From Planning and Preparation to Grant Application and Publication. (2015). Netherlands: Elsevier Science.
2. Arora, R. (2004). Encyclopedia of Research Methodology in Biological Sciences. India: Anmol Publications Pvt. Limited.

3. Handbook of Research Methodology: A Compendium for Scholars & Researchers. (2017). Educreation Publishing.

4. Kumar, R. (2010). Research Methodology: A Step-by-Step Guide for Beginners. United Kingdom: SAGE Publications.

**MB 531 RM -PR: Research Methodology**

Total: 2 Credits Workload :-30hrs/credit

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

| Credit Title and Contents | Number of credits | Number of hours |
|---|---|---|
| Seminar presentations, group activities, and scientific writing sessions based on above theory course. These will include but not limited to- | 2 | 60 |

| | | |
|---|---|---|
| 1. Use of search engines for scientific data mining.<br>2. Use of reference management tools.<br>3. Preparing power point presentation.<br>4. Statistical data analysis using software.<br>5. Presenting a research article.<br>6. Writing an abstract for a research paper.<br>7. Preparing a graphical abstract using software.<br>8. Writing a concept note for research project.<br>9. Scientific poster preparation & presentation.<br>10. Writing a scientific news article or a science blog.<br>11. Preparing and scientoon.<br>12. Participating in group discussions, conferences, symposia etc. | | |

**MB 510 MJ- TH: Microbial Extremophiles**

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**<br>1. Diversity of Extremophiles.<br>2. Microbial forms of extremophiles in various habitats.<br>3.Sample Collection, Enrichment, isolation, classification,<br>4. Properties, and application of extremophiles: Thermophiles, Psychrophiles, Acidophiles and Alkaliphiles.<br>5. Adaptation mechanisms of extremophiles. | 1 | 15 |
| II | **Microbial Extremophiles II** | 1 | 15 |

| | | | |
|---|---|---|---|
| | 1. Sample Collection, Enrichment, isolation, classification, properties, and application of extremophiles: Halophiles, Piezophiles (Barophiles), Xerophiles and Oligophiles.<br>2. Adaptation mechanisms of extremophiles.<br>3. Biotechnological Applications of extremophilic Bacteria.<br>4. Recent developments in extremophilic Bacteria. | | |

**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 MJ -PR: Practicals based on MB 510 MJ-TH Microbial Extremophiles

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)**<br>1.Sample Collection, Processing and Isolation.<br>2.Morphological characterization of indigenous isolates based on staining techniques.<br>3. Identification using Biochemical Tests (Using Bergey's Manual).<br>(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)**<br>1.Sample Collection, Processing and Isolation.<br>2.Morphological characterization of indigenous isolates based on staining techniques.<br>3. Identification using Biochemical Tests (Using Bergey's Manual).<br>(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 -TH: Microbial communication, Membrane transport and signal transduction**

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**<br>1. Life cycle of *Dictyostelium discoideum*, Molecular mechanism of quorum sensing in slime molds.<br>2. Life cycle of myxobacteria, Molecular mechanism of quorum sensing in myxobacteria.<br>3. Quorum sensing in Gram positive and Gram-negative bacteria.<br>4. Biofilms, their organization, signals involved in their formation and dispersal.<br>5. Applications of study on biofilms in pathogenic and non-pathogenic environments. | 1 | 15 |
| II | **Membrane transport and signal transduction** | 1 | 15 |

| | | | |
|---|---|---|---|
| | 1.The composition and architecture of membranes, Membrane dynamics<br>2.Solute transport across membranes: Passive diffusion, facilitated transport, primary and secondary active transport using P, V and F type ATPases<br>3. Ionophores, Ion mediated transport, transport of ions across membranes (ion pumps), ligand and voltage gated ion channels<br>4. Liposomes and model membrane Signal transduction pathways in bacteria, second messengers, regulation of signaling pathways, bacterial two-component systems, chemotaxis. | | |

**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 Multicellular Morphogenesis, 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 MJ -PR: Practicals Based on MB 511 MJ-TH Microbial communication, Membrane transport and signal transduction**

Total:2 Credits Workload :-15hrs./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 | 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 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**<br>1. Crystal violet assay for estimation of biofilm formation<br>2. Bioassay for determination of quorum sensing signals produced by bacteria.<br>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**<br>1.Study principles of osmosis and diffusion using artificial membranes (dialysis membrane) (explain how various physical and chemical factors affect the diffusion)<br>2. Different methods of cell disruption.<br>3.Swab evaluation with respect to transport of bacterial sample | 1 | 30 |

| References |
|---|
| **Practical based on Credit I: Microbial Communication and Coordination among microorganisms**<br>**1. Crystal violet assay for estimation of biofilm formation:**<br>1. O'Toole G. A. (2011) Microtiter dish biofilm formation assay. Journal of Visualized Experiments. 47:3–5. doi: 10.3791/2437.<br>2. 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.<br>**2. Bioassay for determination of quorum sensing signals produced by bacteria:**<br>1. Martín-Rodríguez A. J. and Fernández J. J. (2016). A bioassay protocol for quorum sensing studies using *Vibrio campbellii*. Bio Protoc. 6: e1866.<br>2. 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.<br>**3. Determination of chemo-taxis responses shown by bacteria.using agar plate or capillary tube method:**<br>1. 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.<br><br>**Practical based on Credit II: Membrane transport and signal transduction**<br><br>**1. Study principles of osmosis and diffusion using artificial membranes (dialysis membrane) (explain how various physical and chemical factors affect the diffusion).**<br><br>**2.** 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.<br>**3.** Stillwell W. (2016). Membrane Transport. An Introduction to Biological Membranes. 23–451. doi: 10.1016/B978-0-444-63772-7.00019-1. PMCID: PMC7182109.<br>**5. Different methods of cell disruption:**<br>https://microbenotes.com/cell-disruption-methods/<br>1. 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:<br>2. 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 -TH Advanced Quantitative Biology**

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

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 MJ -PR : Practicals Based on MB 512 MJ-TH Advanced Quantitative Biology**

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*).<br>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).* | 2 | 60 |

| | | |
|---|---|---|
| 3.Applications of probability distribution (Normal, Binomial and Poisson distributions) to analyze the data.<br>4.Computer applications: Statistical analysis of data – t-Test, ANOVA, Chi square test, F test using computer softwares (Using Microsoft Excel or other software). | | |

**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.Inc..
6. NormanT.J. Bailey Statistical methods in biology, 3rdEd. Cambridge University.
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 McNeiland Linda M. Harvey 2008 John Wiley & Sons, Ltd. ISBN:978-0-470-01434-9.


**MB 513 MJ-TH: Experimental Design and Quantitative approach for Biologists**

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 | Gain knowledge about research methodology in detail. |
| CO 2 | Hypothesize the probabilistic statements and make predictions about the data under study. Perform comparative study about different types of mathematical functions. |

| | |
|---|---|
| CO 3 | Able to identify, select, and tabulate data under Correlate exponential function and bacterial growth. |
| CO 4 | Able to learn experimental designs and understand improved process and able to build confidence making informed decisions about the data. Correlate exponential function and bacterial death. |
| CO 5 | Understand the relationships between multiple input and output variables. Understand the mathematical basis of 12-D concept in autoclaving. |
| CO 6 | Understand the term epidemiology, will also be able to use, comment and criticize various epidemiological methods. Apply differentiation and integration in biology. Apply mathematical and computational skills in real life. |

| Credit | Credit Title and Contents | Number of Credits | Number of hours |
|---|---|---|---|
| I | **Design of Experiments:**<br>1.Sampling methods (Random and non-random), sampling errors<br>2.Survey design, DOE in Agriculture, principles (randomization, replication and local control), types of experimental designs (CRD, RCBD and LSD )<br>3. Factorial design (Full, Fractional and Plackett Burman).<br>4. Epidemiological Study designs: Case control, cohort, concurrent, cross-sectional, retrospective/prospective.<br>5. Clinical/field trials-Randomization, Bias removal (Blinding single and double), controlled and uncontrolled trials. | 1 | 15 |
| II | **Quantitative approach for Biologists**<br>1. Concept of Real numbers and Imaginary numbers (1 lecture).<br>2.Dependent and Independent variables and concept of Mathematical Function, symbolic representation of function as f(x) etc.<br>3.Different types of Functions:<br>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 logN=logN0+ Kt and many more). | 1 | 15 |

| | | | |
|---|---|---|---|
| | 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)<br>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)<br>4. Introduction to Differentiation and Integration. Applications in Biology.<br>Note: No descriptive questions on this syllabus. Only solving the problems. | | |

| 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 MJ -PR : Practicals Based on MB 513 MJ-TH Experimental Design and Quantitative approach for Biologists**

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

| | | |
|---|---|---|
| g) Conclusion of Survey<br>(Actual statistical survey need to be carried out to demonstrate its mechanism)<br>4. Factorial Study Design (Plackett-Burman, Fractional Factorial and full factorial) for Optimization of Media conditions.<br>a. Data collection from Research Papers/Dissertations/Journals<br>b.Data Treatment using Statistical Software's (Microsoft Excel, Minitab, SPSS and Design Expert)<br>( Sr.no.1 is compulsory, select any one from sr.no.2 to 4) | | |
| **Practicals based on theory credit Quantitative approach for Biologists**<br>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.<br>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.<br>(Using Statistical Packages) | 1 | 30 |

**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, Publicatio 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-TH – Molecular Biology-I**

Compulsory Theory Paper

Total: 4 Credits Workload: -15 hours /credit

(Total Workload: - 4 credits x 15 hours = 60 hours 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 and Contents** | **Number of Credits** | **Number of Hours** |
|---|---|---|---|
| **I** | **Genome organization:**<br>1. Prokaryotic Genome organization, DNA replication, Mutagenesis and DNA repair.<br>2. Eukaryotic Genome organization, DNA replication, Chromatin remodeling, Histone modification and its effect on the function of chromatin, C value paradox, Rot and Cot concept, pseudogenes.<br>3. Transcription and Regulation in Prokaryotes and Eukaryotes: RNA polymerases, transcription unit, positive and negative regulation, role of attenuators, anti-termination. | 1 | 15 |

| | | | |
|---|---|---|---|
| **II** | **Prokaryotic & Eukaryotic Translation:**<br>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.<br>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. | 1 | 15 |
| **III** | **Recombinant DNA Technology:**<br>1. Enzymes used in Recombinant DNA technology; Restriction endonuclease, DNA ligase, T4 DNA polymerase, Terminal transcriptase, Alkaline phosphatase, polynucleotide kinase.<br>2. Cohesive and blunt end ligation, linkers; adaptors; homopolymeric tailing labeling of DNA:<br>3. Nick translation, random priming, radioactive and nonradioactive probes.<br>4. Hybridization techniques: Northern, Southern, south-western and far-western and colony hybridization, fluorescence in situ hybridization.<br>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).<br>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:**<br>1. Molecular Techniques: yeast two and three hybrid assay, Activity gel assay, DNA helicase assay, Chromatin Immuno-precipitation (ChIP), Designing probe, Epitope tagging.<br>2. Introduction to Microarray and array techniques, the lab-on-a- chip concept.<br>3. Use of array techniques detection of polygenic diseases and diseases-associated changes in gene expression.<br>4. Detection of RNA signatures of _Antibiotic Resistance‘ in bacteria.<br>5. Detection of micro RNA (mi RNA): A signature of cancer diagnostics. | 1 | 15 |

| References |
|---|
| 1. Ko, T., Oliveira, M.M., Alapin, J.M., Morstein, J., Klann, E., & Trauner, D. (2022). Optical Control of Translation with a Puromycin-Photoswitch. *bioRxiv*.<br>2. Aviner R. The science of puromycin: From studies of ribosome function to applications in biotechnology. Comput Struct Biotechnol J. 2020 Apr 24;18:1074-1083. doi: 10.1016/j.csbj.2020.04.014. PMID: 32435426; PMCID: PMC7229235. |
| 3. Xu Y, Li Z. CRISPR-Cas systems: Overview, innovations and applications in human disease research and gene therapy. Comput Struct Biotechnol J. 2020 Sep 8;18:2401-2415. doi: 10.1016/j.csbj.2020.08.031. PMID: 33005303; PMCID: PMC7508700.<br>4. Gupta, Shagun & Ramesh, Kritika & Ahmed, Suhaib & Kakkar, Vipan. (2016). Lab-on-Chip Technology: A Review on Design Trends and Future Scope in Biomedical Applications. International Journal of Bio-Science and Bio-Technology. 8. 311-322. 10.14257/ijbsbt.2016.8.5.28.<br>5. Benjamin Lewin. (2008) Genes IX, Jones and Bartlett Publishers Inc.<br>6. S.B Primrose and R M Twyman 2006 7th edition. Blackwell publishing<br>7. James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann,<br>8. Michael Levine, Richard Loswick (2004) Molecular Biology of the Gene, 5th Edition, Pearson Education, Inc.<br>9. Molecular Biology of the Cell, Bruce Albert et. al., 6th Ed., Garland Sciences.<br>10. Molecular Biology, Loddish et. al., 7th Edn., W. H. Freeman, 2012<br>11. Weaver R., (2007) Molecular Biology, 4th Edition, McGrew Hill Science.<br>12. B. R. Glick, J.J. Pasternack, Principles and applications of recombinant DNA, 3rd Ed., ASM press. |

## MB 552 MJ –TH : Enzymology, Bioenergetics and Metabolism

Total: 4 Credits Workload: -15 hours. /Credit

(Total Workload: -4 credits x 15 hrs. = 60 hours 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 and Contents | Number of Credits | Number of hours |
|---|---|---|---|
| I | **Enzymology**<br>1. Overview: Purification of enzyme, purification chart.<br>2. Overview: MM Equation and Kinetic Plots.<br>3. Kinetics of reversible inhibitions: Competitive, uncompetitive, non-competitive, mixed, substrate. Primary and secondary plots, Determination of Ki using secondary plots. Significance of inhibitors.<br>4. King Altman approach to derive – two substrate enzyme catalyzed reactions.<br>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. | 1 | 15 |
| II | **Bioenergetics**<br>1. Overview: Laws of thermodynamics, entropy, enthalpy, free energy, and equilibrium constant with reference to biological significance.<br>2. Gibbs free energy equation.<br>3. Determination of free energy of hydrolytic and biological oxidation reduction reactions under standard and non-standard conditions.<br>4. Overview of High Energy Compounds.<br>5. Coupled reactions.<br>6. Determination of feasibility of reactions.<br>7. Problems based on 2, 3 and 6.<br>8. Atkinson‘s energy charge. | 1 | 15 |
| III | **Lipid and Carbohydrate Metabolism**<br>1. Synthesis of lipids: Phospholipids and triacylglycerols,<br>2. Synthesis of membrane lipids: Glycerophospholipids, sphingolipids, sterols.<br>3. Degradation of fatty acids (alpha, beta and Omega oxidation and unsaturated fatty acids).<br>4. Lipids as signal molecules (eg. phosphatidylinositol, eicosanoids). | 1 | 15 |

| | | | |
|---|---|---|---|
| | 5. Overview of Glycolysis and gluconeogenesis.<br>6. Regulation of glycolysis and gluconeogenesis.<br>7. Cellulose synthesis and breakdown.<br>8. Glycogen synthesis & breakdown, and its regulation.<br>10. Metabolic flux and its regulation by various metabolic intermediates.<br>11. TCA cycle- regulation, Role in generating biosynthetic intermediates and glyoxylate cycle. | | |
| **IV** | **Micronutrients and Hormones**<br>A. Structure, function of following micronutrients in metabolism.<br>1. Water soluble vitamins and their coenzyme forms (Niacin, Riboflavin, Pantothenic acid, Thiamine, Pyridoxal, Vitamin B12, Folic acid, Glutathione).<br>2. Fat soluble vitamins (A, D, E, and K) .<br>3. Minerals as vitamins (Iron, Manganese, Magnesium, Cobalt, Molybdenum, Copper, Zinc, Nickel.<br>B. The chemical structure and functions of each hormone in connection with the gland responsible for its production:<br>1. The parathyroid 2. The pancreas 3. The adrenals 4. The pituitary glands 5. Sex hormones. | 1 | 15 |

**References**

1. Nelson D. L. and Cox M. M. (2005) Lehninger‘s Principles of Biochemistry, Fourth edition W.H. Freeman & Co. New York.
3. Palmer Trevor (2001) Enzymes: Biochemistry, Biotechnology and Clinical chemistry, Horwood Pub. Co. Chinchester, England.
4. Segel Irvin H. (1997) Biochemical Calculations 2nd Ed., John Wiley and Sons, New York
5. Garrett, R. H. and Grisham, C. M. (2004) Biochemistry. 3rd Ed. Brooks/Cole, Publishing Company, California.
6. Michael T. Madigan, John M. Martinko, David A. Stahl, David P. Clark (2012) Brock Biology of Microorganisms, Thirteenth edition, Benjamin Cummings, San Francisco.
7. Moat Albert G. and Foster John W. (1988) Microbial Physiology 2nd Ed. John Wiley
8. Berg Jeremy, Tymoczko John, StryerLubert (2001) Biochemistry 4th Ed, W. H. Freeman, NY.
9. White David (2000) Physiology and Biochemistry of Prokaryotes. 2nd Ed. Oxford University Press, New York. 2. Mandelstam Joel and McQuillen Kenneth (1976) Biochemistry of Bacterial Growth, Blackwell Scientific Publication London.

**MB 553 MJ -TH -Laboratory Techniques and Instrumentation**

Compulsory Theory Paper

Total: 2 Credits Workload: -15 hours /credit

(Total Workload: -2 credits x 15 hours = 30 hours 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. |

| **Credits** | **Credit Title and Contents** | **Number of Credits** | **Number of hours** |
|---|---|---|---|
| **I** | **Separation and analysis of biomolecules**<br>1. Techniques for sample preparation: Dialysis, ultra-filtration, centrifugal vacuum concentration.<br>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.<br>3. Electrophoresis Methods: Agarose, Native PAGE, SDS PAGE, Pulse field gel electrophoresis, capillary electrophoresis, iso-electric focusing, 2-dimensional electrophoresis, immunoelectrophoresis.<br>4.Principle and applications of X- Ray crystallography Spectroscopy. | 1 | 15 |
| **II** | Introduction: Electromagnetic spectrum, Atomic orbitals, Molecular orbitals, Electronic, Rotational, and Vibrational transitions in spectroscopy, Interpretation of spectra.<br>1. UV/Visible spectroscopy Instrumentation, Molar Absorptivity, Beer and Lambert's Law, Bathochromic and hypochromic shifts. | 1 | 15 |

| | | | |
|---|---|---|---|
| | 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.<br>4. Mass spectroscopy- Principles of operation, Ionization, Ion fragmentation, Mass Analysers.<br>5. Principle and applications of NMR. | | |

**References**


1. Clive Dennison (2002) *A guide to protein isolation*, Kluwer Academic Publishers .

2. Pattabhi,V. and Gautham,N. (2002) *Biophysics.* Kluwer Academic Publishers, New York and Narosa Publishing House, Delhi.

3. David J Holme, Hazel Peck (1998) *Analytical Biochemistry,* 3rdEd. Prentice Hall, Pearson Education Limited, Harlow England.

4. Rodney F. Boyer (2000*) Modern Experimental Biochemistry* 3rd edition., Benjamin Cummings .

5. Nölting, B. (2006) *Methods in modern biophysics.* Second Edition. Springer, Germany.

6. Wilson Keith and Walker John (2005) *Principles and Techniques of Biochemistry and Molecular Biology,* 6th Ed. Cambridge University Press, New York.

7. Rolf Ekman, Jerzy Silberring, Ann Westman-Brinkmalm, Agnieszka Kraj (2009) *Mass spectrometry: instrumentation, interpretation, and applications*, John Wiley & Sons, Inc., Canada.

8. Irwin H. Segel (1976) *Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry,* 2nd Edition. JohnWiley & Sons.

9. David M Webster (2000) *Protein Structure Prediction-Methods and Protocols*, Methods In Molecular Biology Vol 143 Humana Press.

10. Narayanan, P. (2000) Essentials of Biophysics. New Age International Publication, New Delhi.

11. Christof M. Niemeyer and Chad A. Mirkin (2006) *Nanobiotechnology,* JohnWiley & Sons.

12. Daniel L. Feldheim and Colby A. Foss,Jr. *(2002) Metal nanoparticles synthesis and characterization and applications* Marcel Dekker, Inc.

13. Mahendra Rai and Nelson Duran (2011) *Metal nanoparticles in Microbiology*, Springer Verlag Berlin Heidelberg.

14. Sohier, J. Laurent, C., Chevigné, A., Pardon, E., Srinivasan, V., Wernery, U. Galleni, M. (2013) Allosteric Inhibition of VIM Metallo-β-Lactamases by Camelid Nanobody. Biochemical Journal, 450(3), 477-486. doi:10.1042/bj20121305.

15. Chakravarty, R., Goel, S., & Cai, W. (2014). Nanobody: The ―Magic Bullet for Molecular Imaging? Theranostics, 4(4), 386-398. doi:10.7150/thno.8006.

**MB 554 MJ –PR : Practicals based on MB 551 MJ-TH Molecular Biology I, MB 552 MJ-TH Enzymology, Bioenergetics and Metabolism and MB 553 MJ-TH Laboratory Techniques and Instrumentation**

**Compulsory Practical Paper**

Total:4 Credits Workload: -30 hrs/credit

(Total Workload:-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 preparations for cellular extraction of biomolecules and their purification. |
| CO 3 | Experience a hands-on approach and the troubleshooting during processing of the 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, its quantitation and characterization by gel electrophoresis.<br>2.Restriction digestion of plasmid DNA and construction of its restriction digestion map.<br>3.Curing of bacterial Plasmid<br>4.Bacterial Gene annotation using bioinformatics tool-GenBank&UniProt.<br>5.Isolation and characterization of lipase/cellulase/chitinase producing microbe .<br>6.Purification of enzymes using ammonium sulphate precipitation/ Gel Filtration, Establishment of enzyme purification chart.<br>7. Purification of enzymes using organic solvent precipitation, Establishment of enzyme purification chart<br>8.Determination of Km, Vmax and Kcat values of enzyme.<br>9. Determination of molar extinction coefficient of biomolecule<br>10. Isolation of Aflatoxin producing organism. Extraction and detection of Aflatoxin in food.<br>11. Demonstration of SDS-PAGE for purification of proteins. | 4 | 120 |

| | | |
|---|---|---|
| 12.Paper and thin layer chromatography technique for the separation of amino acids from a biological sample.<br>13.Paper and Thin layer chromatography technique for separation of Sugars from biological sample (two dimensional).<br>14.Virtual lab exercise to understand the instrumentation, experimentation and interpretation of data obtained using MALDI TOF/ FTIR.<br>15.Virtual lab exercise/ Visit to understand the instrumentation, experimentation and interpretation of microscopy data (SEM, TEM, AFM). | | |

**References**

1. Delaney S., Murphy R. and Walsh F. (2018). A comparison of methods for the extraction of plasmids capable of conferring antibiotic resistance in a human pathogen from complex broiler cecal samples. Frontiers in microbiology.9: 1731. https://doi.org/10.3389/fmicb.2018.01731.

2. Sambrook J. and Russell D. (2001) Molecular Cloning: A Laboratory Manual, 3rd edition. Cold Sprving Harbor, NY: Cold Spring Harbor Laboratory Press.

3. Russell P. J. (2010). iGenetics: A Molecular Approach. 3rd edition. Pearson Education, Inc., publishing as Pearson Benjamin Cummings, San Francisco.

4. Watson J. D., Gann A., Baker T. A., Levine M., Bell S. P., Losick R. and Harrison S.C. (2014). Molecular Biology of the genes.7th edition. Cold Spring Harbor Laboratory Press. Cold Spring Harbor, New York.

5. Paul D., Dhar (Chanda) D., Chakravarty A. and Bhattacharjee A. (2020). An insight into analysis and elimination of plasmids encoding metallo-β-lactamases in *Pseudomonas aeruginosa*. Journal of Global Antimicrobial Resistance. 21: 3-7. https://doi.org/10.1016/j.jgar.2019.09.002.

6. Trevors J. T. (1986). Plasmid curing in bacteria. FEMS Microbiology Reviews 32:149-157.

7. Archer C.T., Kim J.F., Jeong H., Park J. H., Vickers C. E., Lee S. Y. and Nielsen L. K.(2011). The genome sequence of E. coli W (ATCC 9637): comparative genome analysis and an improved genome-scale reconstruction of E. coli. BMC Genomics.12: 9. https://doi.org/10.1186/1471-2164-12-9.

8. Webster D. M. (Editor). Protein Structure Prediction: Methods and Protocols. In: Methods in Molecular Biology; Volume 143. Humana Press.

9. Akardere E., Özer B., Çelem E. B. and Önal S. (2010). Three-phase partitioning of invertase from Baker's yeast.Separation and Purification Technology. 72(3): 335-339. https://doi.org/10.1016/j.seppur.2010.02.025.

10. Baltas N., Barbaros D., Pinar E. A., Sevgi K. and Ahmet A. (2016). Purification and characterization of extracellular α-amylase from a thermophilic *Anoxybacillus thermarum* A4 strain. Brazilian Archives of Biology and Technology. 59: e16160346. https://doi.org/10.1590/1678-4324-2016160346.

11. Scopes R. K. (1994) Protein Purification Principles and Practice. Third Edition, Springer

12. Syed D. G., Agasar D. and Pandey A. (2009). Production and partial purification of α-amylase from a novel isolate *Streptomyces gulbargensis*. Journal of Industrial Microbiology and Biotechnology. 36(2): 189–194. https://doi.org/10.1007/s10295-008-0484-9.

13. Miquet J. G., González L., Sotelo A. I. and González Lebrero R. M. (2019). A laboratory work to introduce biochemistry undergraduate students to basic enzyme kinetics-alkaline phosphatase as a model. BiochemMolBiol Educ. 47(1):93-99. doi: 10.1002/bmb.21195.

14. Palmer T. and Bonner P. L. (2007). Enzymes: Biochemistry, Biotechnology, Clinical Chemistry. United Kingdom: Elsevier Science.

15. Miranda-Hernández M. P., Valle-González E. R., Ferreira-Gómez D., Pérez N. O., Flores-Ortiz K. F. and Medina-Rivero E. (2016). Theoretical approximations and experimental extinction coefficients of biopharmaceuticals. Anal Bioanal Chem. 408:1523–1530 https://doi.org/10.1007/s00216-015-9261-6.

16. Wilson K. and Walker J. (2005) Principles and Techniques of Biochemistry and Molecular Biolog. 6th edition. Cambridge University Press, New York.

17. Adetunji M. C., Alika O. P., Awa N. P., Atanda O. O and Mwanza M. (2018). Microbiological quality and risk assessment for aflatoxins in groundnuts and roasted cashew nuts meant for human consumption. Journal of Toxicology.2018: Article ID 1308748. https://doi.org/10.1155/2018/1308748.

18. Fakruddin M., Chowdhury A., Hossain M. N. and Ahmed, M. M. (2015). Characterization of aflatoxin producing *Aspergillus flavus* from food and feed samples. SpringerPlus. 4:159. https://doi.org/10.1186/s40064-015-0947-1.

19. Braicu C., Puia C., Bodoki E. and Socaciu C. (2008). Screening and quantification of aflatoxins and ochratoxins in different cereals cultivated in Romania using thin-layer chromatography- densitometry. Journal of Food Quality. 31: 108-120. https://doi.org/10.1111/j.1745- 4557.2007.00187.

20. Wacoo A. P., Wendiro D., Vuzi P. C. and Hawumba J. F. (2014). Methods for detection of aflatoxins in agricultural food crops. Journal of Applied Chemistry. 2014: Article ID 706291. https://doi.org/10.1155/2014/706291.

21. Feng W., Wang X. Q., Zhou W., Liu G. Y. and Wan Y. J. (2011). Isolation and characterization of lipase-producing bacteria in the intestine of the silkworm, *Bombyx mor*i, reared on different forage. J Insect Sci.11: 135. doi: 10.1673/031.011.13501.

22. Ilesanmi O. I., Adekunle A. E., Omolaiye J. A, Olorode E. M. and Ogunkanmi A. L. (2020).Isolation, optimization and molecular characterization of lipase producing bacteria from contaminated soil.Scientific African.8; e00279. https://doi.org/10.1016/j.sciaf.2020.e00279.

23. Islam F. and Roy N. (2018). Screening, purification and characterization of cellulase from cellulase producing bacteria in molasses.BMC Res Notes. 11(1):445. doi: 10.1186/s13104-018- 3558-4.

24. Sulyman A. O., Igunnu A. and Malomo S. O. (2020). Isolation, purification and characterization of cellulase produced by *Aspergillus niger* cultured on *Arachishypogaea* shells. Heliyon. 6: 12: e05668.https://doi.org/10.1016/j.heliyon.2020.e05668.

25. Nagpure A., Choudhary B. and Kumar S. (2014). Isolation and characterization of chitinolytic *Streptomyces* sp. MT7 and its antagonism towards wood-rotting fungi. Ann. Microbiol. 64, 531–541. https://doi.org/10.1007/s13213-013-0686-x.

26. Shahbaz U. and Yu X. (2020).Cloning, isolation, and characterization of novel chitinase-producing bacterial strain UM01 (*Myxococcus fulvus*).J Genet EngBiotechnol.18, 45. https://doi.org/10.1186/s43141-020-00059-1.
27. Carr P. W. and Stoll D. R. (2015). Two-dimensional liquid chromatography: Principles, practical implementation and applications. Primer.Agilent Technologies. Germany. https://www.agilent.com/cs/library/primers/public/5991-2359EN.pdf
28. Jayaraman J. (2004). Laboratory Manual in Biochemistry. India: New Age International (P) Limited Publishers.
29. Plummer M. and Plummer D.T. (2001). Introduction to practical biochemistry. 3rd Edition,Tata McGraw- Hill Edition.
30. Sadasivam S. and Manickam A. (2008). Biochemical methods. 3rd Edition, New Age International Publishers, India.
31. John Coates. (2000). Interpretation of Infrared Spectra, A Practical Approach. Encyclopedia of Analytical Chemistry. R.A. Meyers (Ed.), John Wiley & Sons Ltd.

## MB 560 MJ -TH: Molecular biology tools and applications

Total: 2 Credits Workload: -15 hours. /Credit

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

| Course outcomes COs | |
|---|---|
| **After studying the course learners will be able to** | |
| CO1 | Explain principle and procedures of various molecular techniques. |
| CO2 | Explain the concept of microarray. |
| CO3 | Describe various hybridization techniques. |
| CO4 | Explain the concept of recombinant DNA technology. |
| CO5 | Describe the use of Biopolymers. |

| Credit | Credit Title and Contents | Number of Credits | Number of hours |
|---|---|---|---|
| I | **Tools in Molecular Biology**<br>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.<br>2. DNA microarray, Construction of microarrays – genomic arrays, cDNA arrays and oligo arrays.<br>3. Super shift assay and EMSA, Sequence tagged sites, Filter binding assay, Protein foot printing, finding the replicon, DNA fingerprinting, Measuring transcription rates<br>4. Hybridization techniques: Free solution, membrane based (DOT blot, SLOT blot), Fluorescence in situ hybridization (FISH) and Microarray technology. | 1 | 15 |
| II | **Applications of recombinant DNA technology in** | 1 | 15 |

| | | | |
|---|---|---|---|
| | **production of**<br>1. Synthesis of commercial products: Amino acids (L-Valine and L-cysteine), ascorbic acid, Peptide antibiotics.<br>2. Hybrid Human-Mouse monoclonal antibodies, Human monoclonal antibodies, anti-cancer antibodies.<br>3. Biopolymers: gum, rubber, polyhydroxy alkanoates.<br>4. Un-conventional microbial systems for production of high quality protein drug. | | |

**References**

1.Alberts B. (2017). Molecular Biology of the Cell. Publisher: W.W. Norton. United States.
2.Blalock E. M. (2011). A beginner‘s guide to microarrays. United States. Springer US.
3. Burton D. R., Silverman G. J. and Barbas C. F. (2004). Phage Display: A Laboratory Manual. United States: Cold Spring Harbor Laboratory Press.
4. Cooper G. M. and Hausman R. E. (2016). The Cell: A Molecular Approach. United Kingdom: Oxford University Press, Incorporated.
5. Dale J. W., von Schantz M., Plant N. and Plant N. (2012). From genes to genomes: concepts and applications of DNA technology. United Kingdom: Wiley.
6. Kolpashchikov D. M. and Gerasimova Y. V. (2016). Nucleic acid detection: methods and protocols. United States: Humana Press.
7. Friedberg E., Lindahl T., Muzi-Falconi M., Elledge S. J. and Lehmann A. (2014). DNA Repair, Mutagenesis, and Other Responses to DNA Damage: A Subject Collection from Cold Spring Harbor Perspectives in Biology. United States: Cold Spring Harbor Laboratory Press.
8. Fu H. (2004). Protein-protein Interactions: Methods and Applications.Ukraine: Humana Press.
9. García-Cañas V., Simó C. and Cifuentes A. (2014). Fundamentals of advanced omics technologies: from genes to metabolites. Netherlands: Elsevier Science.
10. Glick B. R. and Patten C. L. (2017). Molecular Biotechnology: Principles and Applications of Recombinant DNA. India: Wiley.
11. Goldstein E. S., Krebs J. E. and Kilpatrick S. T. (2017). Lewin's GENES XII. United States: Jones & Bartlett Learning.
12. Kalia V. C. (2016). Microbial Factories: Biodiversity, Biopolymers, Bioactive Molecules: Volume 2. India: Springer India.
13. Kurnaz I. A. (2015). Techniques in Genetic Engineering. United Kingdom: CRC Press.
14. Leblanc B. and Moss T. (2010). DNA-Protein Interactions: Principles and Protocols. Third Edition. United States: Humana Press.
15. Lilley D. M. J. and Eckstein F. (2012). Nucleic Acids and Molecular Biology. Germany: Springer Berlin Heidelberg.
16. Lodish H., Berk A., Kaiser C. A., Krieger M., Bretscher A., Ploegh H., Amon A. and Martin K. C. (2016). Molecular Cell Biology. United States: Macmillan Learning.
17. Müller U. R. and Nicolau D. V. (2006). Microarray technology and its applications. Germany: Physica-Verlag.

18. Rice P. A. and Correll C. C. (Editors). (2008). Protein-Nucleic Acid Interactions: Structural Biology. United Kingdom: Royal Society of Chemistry.

19. Seitz H. (Editor). (2007). Analytics of Protein-DNA Interactions. Germany: Springer.

20. Sharp D., Sikorski E. and Plopper G. (2013). Lewin's CELLS. United States: Jones & Bartlett Learning.

21.Stanbury P. F., Whitaker A. and Hall S. J. (2016). Principles of Fermentation Technology. Netherlands: Elsevier Science.

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 MJ -PR: Practicals based on MB 560 MJ-TH Molecular Biology tools and application

Total: 2 Credits Workload: -30 hours. /Credit

(Total Workload: -2 credits x30 hrs=60 hrs in semester)

| Course outcomes COs | |
|---|---|
| **After studying the course learners will be able to** | |
| CO1 | Explain principle and procedures of various molecular techniques. |
| CO2 | Explain the concept of microarray. |
| CO3 | Describe various hybridization techniques. |
| CO4 | Explain the concept of recombinant DNA technology. |
| CO5 | Describe the use of Biopolymers. |

| Credit Title and Contents | Number of Credits | Number of hours |
|---|---|---|
| 1. Cloning/ transformation using plasmid vectors- GFP gene cloning/ blue and white screening:<br>i. Vector and Insert Ligation.<br>ii. Preparation of competent cells .<br>iii. Transformation of E. coli with standard plasmids.<br>iv. Calculation of transformation efficiency.<br>2. PCR amplification.<br>3. Purification of 16S rRNA gene.<br>4. PCR Primer Design. | 2 | 60 |
| 5. Protoplast fusion. | | |

| | | |
|---|---|---|
| 6. Activity staining analysis (Zymograms) (NATIVE PAGE).<br>7. FTIR analysis of a biomolecule/recombinant molecule (at least five different molecules).<br>8. Production by recombinant strain and estimation of Biopolymers:<br>i. Gum<br>ii. Polyhydroxyalkanoates (PHB) | | |

**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.

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 bluewhite colony screening Genetics and Molecular Research 15 (2): gmr.15027925. http://dx.doi.org/10.4238/gmr.15027925

**2. 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 rRNAseq 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.

**3. 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.

**4. 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.

5. **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).

**6. 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.

**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.

**b.) Recombinant molecules**

**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

**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

**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
Isolation and estimation of RNA from bacterial cell https://medicine.yale.edu/keck/ycga/images/trizolrnaisolation_092107_tcm240-21453.pdf.

## MB 561 MJ-TH Nitrogen Metabolism, Respiration and Photosynthesis

Total: 2 Credits Workload: -15 hours. /Credit

(Total Workload: -2 credits x 15 hrs. = 30 hours 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 anoxygenic photosynthesis mechanism |

| Credit | Credit Title and Contents | Number of Credits | Number of hours |
|---|---|---|---|
| I | **Nitrogen Metabolism:**<br>1. Biochemistry of biological nitrogen fixation, properties of nitrogenase and its regulation.<br>2. Ammonia assimilation, glutamine synthetase, glutamate dehydrogenase, glutamate synthetase, their properties and regulation.<br>3.Biosynthesis of five families of amino acids and histidine<br>4. Biosynthesis of purine and pyrimidine bases.<br>5. Protein turnover and amino acid degradation. | 1 | 15 |
| II | **Respiration and photosynthesis:**<br>1. Respiration: Respiration in chemolithotrophs, sulphur oxidisers, nitrate reducers with respect to electron transport chain and energy generation, Biochemistry of methanogens.<br>2. Photosynthesis:<br>a. Overview: Plant Photosynthesis.<br>b.Bacterial Photosynthesis: photolithotrophs, photosystems<br>c. Bacterial (cyclic, non-cyclic) photophosphorylation in various groups of phototrophic bacteria.<br>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 MJ -PR -Practicals based on MB 561 MJ-TH Nitrogen Metabolism, Respiration and Photosynthesis**

Total: 2 Credits Workload:-30 hours /credit

(Total Workload:-2 credits x 30hrs=60 hours 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 and Contents | Number of Credits | Number of hours |
|---|---|---|
| 1. Isolation of IAA producing organism, Detection of Indole acetic acid production by microorganism.<br>2. Detection of siderophore production by microorganisms<br>3. Enrichment, Isolation and characterization of nitrogen fixing bacteria.<br>4. Extraction and estimation by Folin Ciocalteu method of<br>a) polyphenols b) tannins<br>5. Enrichment and isolation of lignin/xylan degraders from Soil.<br>6. Enrichment, Isolation, and characterization of Sulphur reducing bacteria/ Methanogens.<br>7. Enrichment, Isolation, and characterization of Cyanobacteria.<br>8. Detection of chlorophyll-a of Cyanobacteria. | 2 | 60 |

**References**

**1. Isolation of IAA producing organism, Detection of Indole acetic acid production by microorganisms: -**

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) producing bacteria from rhizospheric soil and its effect on plant growth. Journal of Soil Science and Plant Nutrition, 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.

Senthilkumar M., Amaresan N.and Sankaranarayanan A.(2021). Detection of siderophore producing microorganisms. In: Plant-Microbe Interactions. Springer Protocols Handbooks. Humana,NewYork,NY.https://doi.org/10.1007/978-1-0716-1080-0_47.

**3. Enrichment, Isolation and characterization of nitrogen fixing bacteria:-**

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 *Strobilanthes Kunthiana* (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.

Zaviel 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 –TH : Molecular Biophysics

Total: 2 Credits Workload: -15 hours. /Credit

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

| Course outcomes COs | |
|---|---|
| After studying the course learners will be able to | |
| CO1 | Understand proper handling of various instruments. |
| CO2 | Know the importance of the use of X-ray crystallography in purification of proteins. |

| | |
|---|---|
| CO3 | Understand application of Radioisotopes in Biology. |
| CO4 | To know the usefulness/Utility of Confocal Microscopy. |

| Credit | Credit Title and Contents | Number of Credits | Number of hours |
|---|---|---|---|
| I | **Biophysical Techniques**<br>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.<br>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**<br>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 .<br>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**

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 MJ- PR : Practicals based on MB 562 MJ -TH Molecular Biophysics**

Total: 2 Credits Workload: -30 hours. /Credit

(Total Workload: -2 credits x30 hrs=60 hrs in semester)

| **Course outcomes COs** | |
|---|---|
| **After studying the course learners will be able to** | |
| CO1 | Understand the Experimentation and interpretation of data using Radioisotopes. |
| CO2 | To solve virtual lab problem-based exercises |
| CO3 | To know the Utility of various instruments. |
| CO4 | Learn the use of instruments in biophysical techniques. |

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

**References**

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 -TH: Bioinformatics

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 software in bioinformatics. |

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

**References**

1. Ajawatanawong P. (2017). Molecular Phylogenetics: Concepts for a Newcomer. Adv Biochem Eng Biotechnol.160:185-196. doi: 10.1007/10_2016_49. PMID: 27783136.

2.Benson D. A., Boguski M. S., Lipman D. J., Ostell J. and Ouellette B. F. F. (1998). GenBank. *Nucleic Acids Res*. 26(1):1-7. doi:10.1093/nar/26.1.1.

3. Berman H. M., Gelbin A., Clowney L., Hsieh S. H., Zardecki C. and Westbrook J. (1996). The Nucleic Acid Database: Present and Future. J Res Natl Inst Stand Technol. 101(3): 243-257. doi: 10.6028/jres.101.026. PMID: 27805162; PMCID: PMC4963143

4. Coimbatore Narayanan B., Westbrook J., Ghosh S., Petrov A. I., Sweeney B., Zirbel C. L., Leontis N. B. and Berman H. M. (2014). The Nucleic Acid Database: new features and capabilities. Nucleic Acids Res. 42(Database issue): D114-22. doi: 10.1093/nar/gkt980. Epub 2013 Oct 31. PMID: 24185695; PMCID: PMC3964972.

5. https://pediaa.com/difference-between-upgma-and-neighbor-joining-tree/

6. Kannan L. and Wheeler W. C. Maximum Parsimony on Phylogenetic networks. *Algorithms Mol Biol* **7**. 9 (2012). https://doi.org/10.1186/1748-7188-7-9

7. NCBI Resource Coordinators. (2013) Database resources of the National Center for Biotechnology Information. Nucleic Acids Res. 41(Database issue): D8-D20. doi: 10.1093/nar/gks1189. Epub 2012 Nov 27. PMID: 23193264; PMCID: PMC3531099.

8. Suzek B., Huang H., Mcgarvey P., Mazumder R. and Wu C. (2007). UniRef: Comprehensive and Non-Redundant UniProt Reference Clusters. Bioinformatics (Oxford, England). 23:1282-1288. 10.1093/bioinformatics/btm098.

Wang Y., *et al* (2017). GSA: Genome Sequence Archive. *Genomics Proteomics Bioinformatics.* 15(1):14-18. doi:10.1016/j.gpb.2017.01.001

**MB 563 MJ -PR: Practicals based on MB 563 MJ-TH Bioinformatics**

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 and Contents | Number of Credits | Number of hours |
|---|---|---|
| 1. 16S rRNA gene sequencing analysis of bacteria:<br>2. Isolation, purity checking using A260/A280 ratio and Agarose gel - electrophoresis of isolated chromosomal DNA of bacteria.<br>3. PCR amplification and purification of 16S rRNA gene .<br>4. Demonstration of the following steps, if not possible to perform in your lab: PCR product Sequencing using automated sequencer -Sequence matching by BLAST analysis.<br>5. Drawing phylogenetic tree using related sequences (Using standard software like Phylip, Mega etc. | 2 | 60 |

**References**

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 ClinMicrobiol. 45(9): 2761-2764. doi: 10.1128/JCM.01228-07. Epub 2007 Jul 11. PMID: 17626177; PMCID: PMC2045242.

2.https://assets.thermofisher.com/TFS-Assets/CAD/Product-Bulletins/T123-NanoDrop- Lite-Interpretation-of-Nucleic-Acid-260-280-Ratios.pdf .

3.https://www.biotech.cornell.edu/sites/default/files/2020-07/Full_service_Sanger_Handbook.pdf.

4. Wilson K. H., Blitchington R. B. and Greene R C. (1990). Amplification of bacterial 16S ribosomal DNA with polymerase chain reaction. J ClinMicrobiol. 28(9): 1942-1946. doi: 10.1128/jcm.28.9.1942-1946.1990. Erratum in: J ClinMicrobiol 1991 Mar;29(3):666. PMID: 2095137; PMCID: PMC268083.

5. Kumar S., Nei M., Dudley J. and Tamura K. (2008). MEGA: a biologist-centric software for evolutionary analysis of DNA and protein sequences. Brief Bioinform. 9(4):299-306. doi: 10.1093/bib/bbn017. EpubApr 16. PMID: 18417537; PMCID: PMC2562624.

6. https://blast.ncbi.nlm.nih.gov/Blast.cgi

7. https://www.youtube.com/watch?v=HXEpBnUbAMo

8.https://www.ncbi.nlm.nih.gov/genbank/fastaformat/https://www.ncbi.nlm.nih.gov/genbank/fastaformat/

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 |