Progressive Education Society's

Modern College of Arts, Science and Commerce (Autonomous)

Ganeshkhind, Pune 411016

www.moderncollegegk.org

Structure of the M. Sc. I Microbiology Syllabus

Choice Based Credit System

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, behavioural 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, micro-organisms from extreme environments, Archaebacteria, etc.

· **Mathematical approach for Biologists**: Numerical Microbiology Problem solving, Concept of mathematical models, Application of Mathematical models to microbiological processes

· **Advanced Biochemistry and Molecular Biology Techniques**: Chromatography techniques, next generation sequencing methods (Pyrosequencing, Ion torrent, Nanopore sequencing)

· **Morphogenesis and organogenesis in plants**

· **Research Methodology**: Use of search engines for scientific data mining, use of reference management tools, statistical data analysis using software

To enrich students' knowledge and train them in the above-mentioned areas; we feel certain topics in the present syllabus need to be supplemented and strengthened by inclusion of 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
- Techniques in Bio-nanotechnology
- 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.

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 technological 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 post-graduate student can start work directly in applied fields (industry or institutions), without any additional training.

The college itself will be developing trained and skilled manpower. We are restructuring the syllabus with this viewpoint. The restructured syllabus will combine the principles of chemistry and biological sciences (molecular and cell biology, genetics, immunology and analytical tools, biochemistry, biostatistics and bioinformatics) with technological disciplines to produce goods and services and for environmental management.

Microbiology curricula are operated at two levels viz. undergraduate and postgraduate. The undergraduate curricula are prepared to impart basic knowledge of the respective subject from all possible angles. In addition, students are to be trained to apply this knowledge particularly in day-to-day applications of Microbiology and to get a glimpse of research.

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

A: Course Structure:

A full master's degree course in Sciences would be of 80 credits, where one credit course of theory will be of one clock hour per week, running for 15 weeks and one credit for practical course will consist of 30 clock hours of laboratory exercises. There shall be four semesters and credits are distributed over 4 semesters. There will be 3 core compulsory theory courses (4 credits each) and one core compulsory Practical course (4 credits). In addition to this, choice based optional paper means elective course (departmental course) is offered consisting of 2 theory credits course and allied 2 practical credit course.

B: Workload:

Each theory credit is equivalent to 15 clock hours of teaching (12 hrs classroom + 3 hrs of tutorials-active learning method) and each practical credit is equivalent to 30 clock hours of teaching in a semester.

1. For the purpose of computation of workload, the following mechanism may be adopted as per UGC guidelines:

i) 1 Credit = 1 Theory period of one-hour duration per week

ii) 1 Credit = 1 Tutorial period of one-hour duration per week

iii) 1 Credit = 1 Practical period of two-hour duration per week

2. Each theory lecture time is of 1hour=60min.

3. Each practical session time for Compulsory Practical Paper is of 8 hour=480

min. 4. Each practical session time for Choice Based Practical Optional paper is 4 hour =240min.

C. Course Outline for M. Sc. Microbiology

Semester I

Course Type	Course Code	Course Name	Credit	Assessment		
				CIA	UE	Total
Core Compulsory Theory Papers	**22-MBCT-111**	Microbial Systematics	4	30	70	100
	22-MBCT-112	Quantitative Biology	4	30	70	100
	22-MBCT-113	Biochemistry and Metabolism	4	30	70	100
Core Compulsory Practical paper	**22-MBCP-114**	Biochemical Techniques (Practical based on compulsory theory credits)	4	30	70	100
Choice Based Optional Papers	**22-MBET-115**	Fungal Systematics and Extremophiles	2	15	35	50
	22-MBEP-115	Practicals Based on Fungal Systematics and Extremophiles	2	15	35	50
	OR					
	22-MBET-116	Bioremediation and Biomass Utilization	2	15	35	50
	22-MBEP-116	Practicals Based on Bioremediation and Biomass Utilization	2	15	35	50
	OR					
	22-MBET-117	Nitrogen Metabolism, respiration and Photosynthesis	2	15	35	50
	22-MBEP-117	Practicals based on Nitrogen Metabolism, respiration and Photosynthesis	2	15	35	50

Semester II

Course Type	Course Code	Course Name	Credit	Assessment		
				CIA	UE	Total
Core Compulsory Theory Papers	**22-MBCT-121**	Instrumentation and Molecular Biophysics	4	30	70	100
	22-MBCT-122	Molecular Biology	4	30	70	100
	22-MBCT-123	Cell Organization and Biochemistry	4	30	70	100
Core Compulsory Practical paper	**22-MBCP-124**	Molecular biology, enzymology and instrumentation Techniques (Practical based on compulsory theory credits)	4	30	70	100

Choice Based Optional Papers	**22-MBET-125**	Bioinformatics and Bio-nanotechnology	2	15	35	50
	22-MBEP-125	Practicals based on Bioinformatics and Bio-nanotechnology	2	15	35	50
	OR					
	22-MBET-126	Molecular Biology tools and applications	2	15	35	50
	22-MBEP-126	Practical based on Molecular Biology tools and applications	2	15	35	50
	OR					
	22-MBET-127	Microbial communication, Membrane transport and signal transduction	2	15	35	50
	22-MBEP-127	Practicals Based on Microbial communication, Membrane transport and signal transduction	2	15	35	50

Semester III

Course Type	**Course Code**	**Course Name**	**Credit**	**Assessment**		
				CIA	**UE**	**Total**
Core Compulsory Theory Papers	**23-MBCT-231**	Immunology	4	30	70	100
	23-MBCT-232	Molecular Biology	4	30	70	100
	23-MBCT-233	Clinical Microbiology	4	30	70	100
Core Compulsory Practical paper	**23-MBCP-234**	Practicals Based on Compulsory theory credits	4	30	70	100
Choice Based Optional Papers	**23-MBET-235**	Cell Culture techniques	2	15	35	50
	23-MBEP-235	Practicals Based on Cell Culture techniques	2	15	35	50
	OR					
	23-MBET-236	Experimental Design and Quantitative approaches for Biologist	2	15	35	50
	23-MBEP-236	Practicals based on Experimental Design and Quantitative approaches for Biologist	2	15	35	50
	OR					
	23-MBET-237	Microbial Virus Technology	2	15	35	50
	23-MBEP-237	Practicals Based on Microbial Virus Technology	2	15	35	50

Semester IV

Course	**Course**	**Course**	**Credit**	**Assessment**

Type	Code	Name		CIA	UE	Total
Core Compulsory Theory Papers	**23-MBCT-241**	Pharmaceutical Microbiology	4	30	70	100
	23-MBCT-242	Microbial Technology	4	30	70	100
Core Compulsory Practical paper	**23-MBCP-243**	Dissertation	4	30	70	100
Any TWO Choice Based Optional Papers	**23-MBET-244**	Quality Assurance and Validation in Pharmaceutical Industry and Development of Anti-infectives	2	15	35	50
	23-MBEP-244	Practicals based on quality assurance and validation in pharmaceutical industry and development of Anti-infectives	2	15	35	50
	OR					
	23-MBET-245	Advances in Microbial Technology	2	15	35	50
	23-MBEP-245	Practicals based on Advances in Microbial Technology	2	15	35	50
	OR					
	23-MBET-246	Industrial Waste Water Treatment and Industrial Production of vaccines	2	15	35	50
	23-MBEP-246	Practicals based on Industrial Waste Water Treatment and Industrial Production of vaccines	2	15	35	50
	OR					
	23-MBET-247	Bioethics, Biosafety, Quality control and Quality Assurance	2	15	35	50
	23-MBEP-247	Practicals based on Bioethics, Biosafety, Quality control and Quality Assurance	2	15	35	50

Extra credit Courses for M. Sc.

With Reference to circulars by Savitribai Phule Pune University extra credit courses viz. Cyber security courses of 4 credits, Human Rights Education programme of 2 credits ((Ref: BCUD/76 and Ref: BCUD/77 Dated 18-03-2015), Introduction to constitution of 2 credits (Ref: Circular No. 344/2020), have been incorporated in the syllabi of Post Graduate courses.

Regular students can take extra credit courses from their own department or from other departments. The extra credit courses opted and specified by the students and grades obtained for these courses will be noted on their grade sheets.

Course Code	Course Name
22-192	Cyber security Module-I
22-292	Cyber security Module-II
22-191	Human Rights Module-I
22-291	Human Rights Module-II
23-392	Cyber security Module-III
23-492	Cyber security Module-IV
23-394	Skill Development Module-I
23-494	Skill Development Module-II
23-395	Introduction to Constitution

MB: Microbiology; EP: Practical Elective; ET: Theory Elective; CP: Compulsory.

Theory and Practical Details of courses for Semester III and IV will be declared later.

D: Each course will be evaluated for 25 marks per credit of which 30% will be based on continuous / internal evaluation.

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

F: The formula for GPA will be based on weighted average. The final GPA will not be printed unless a student passes courses equivalent to minimum 80 credit hours. Total credit hours mean sum of credit hours of the courses which a student has passed.

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

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

General Instructions

The post-graduate degree will be awarded to students who obtain a total 80 credits (20 average credits per semester). One credit will be equivalent to 15 clock hours of teacher-student contact per semester.

Assessment shall consist of a) In-semester continuous assessment (CIA) and b) End-semester assessment.

The teacher concerned shall announce the units for which each in-semester assessment will take place.

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

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

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

Semester end examination for remaining 70% marks will be conducted by the Examination department.

The student has to obtain 40% marks in the combined examination of In- semester assessment and Semester-End assessment with a minimum passing of 30% in both these separately.

To pass the degree course, a student shall have to get minimum aggregate 40% marks (E and above grade point scale) in each course.

If a student misses an internal assessment examination, he/she will have a second chance with the permission of the Principal in consultation with the concerned teacher. Such a second chance shall not be the right of the student.

Internal marks will not change. A student cannot repeat Internal assessment. In case he/she wants to repeat internal assessment he/she can do so only by registering for the said course during the 5th / 6^{th} semester and onwards up to 8^{th} semester.

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

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

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

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

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

22-MBCT-111: Microbial Systematics	
CO. No.	**Course Outcomes**

1.	Explain Concept of speciation and species evolution
2.	Explain Microbial diversity
3.	Explain Taxonomy of Bacteria and classification of bacteria by 3 kingdom and 5 domain system, the phonetic and phylogenetic approach for classification.
4.	Explain Concept of 'unculturable' bacterial diversity.
5.	Explain Strategies for culture of 'unculturable' bacteria.
6.	Explain Culture independent molecular methods for identifying unculturable bacteria
7.	Explain Methods of extracting total bacterial DNA from a habitat and metagenome analysis
8.	Explain the concept of evolution, kin selection, game theory, coevolution, molecular evolution, r and k selection.

Unit No.	Title and contents	No. of Lectures
1	**Bacterial Systematics** 1. Species concept in prokaryotes and eukaryotes 2. 5-Kingdom classification system 3. 3-Domain classification system 4. Determinative Bacteriology (Phenetic Approach) 5. Systematic Bacteriology (Phylogenetic Approach) 6. Polyphasic Approach 7. Molecular clocks, phylogeny and molecular distances	**(15)**
2	**Microbial Diversity** 1. Facets of microbial diversity: morphological, structural, metabolic, ecological, behavioral and evolutionary 2. Species divergence and measurement of microbial diversity 3. Measures and indices of diversity; alpha, beta and gamma diversity	**(15)**

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

Suggested References:

1. Microbial Diversity: Form and Function in Prokaryotes, Published Online: 30 NOV 2007. DOI: 10.1002/9780470750490.ch1 Copyright © 2005 by Blackwell Science Ltd
2. Carl R. Woese. The archaeal concept and the world it lives in: a retrospective. Photosynthesis Research 80: 361 – 372, 2004. Kluver Academic Publishers.
3.Brown James. Principles of Microbial Diversity.ASM Press ,2014.
4. Ridley Mark (2004). Evolution. Blackwell Science Ltd.
5. Species Divergence and the measurement of microbial diversity. Catherine Lozupone and Rob Knight. FEMS Microbiol. Rev. 32 (2008) 557 – 578.
6. Methods of studying soil microbial diversity. Jennifer Kirk et al, (2004). Journal of Microbiological Methods 58, 169 – 188.
7. Keller M. and Zengler K. (2004) Tapping in to Microbial Diversity. Nature Reviews 2, 141-
8. Pace N. (1997) A Molecular View of Microbial Diversity and the Biosphere, Science, 276, 734-740.
9. Woese C. (1987), Bacterial Evolution. Microbiological Reviews, 221-271.
10. Breed and Buchanan. Bergey's Manual of Determinative Bacteriology. 8th Edition, 1974.
11. Breed and Buchanan. Bergey's Manual of Determinative Bacteriology. 9th Edition, 1982.
12. Breed and Buchanan. Bergey's Manual of Systematic Bacteriology. 2nd Edition, (Volumes. 1 – 5) (2001 – 2003).
13. Sykes, G. and F. A. Skinner (Eds). Actinomycetales: Characteristics and Practical Importance. Society for Applied Bacteriology Symposium Series No. 2, Academic Press. 1973.
14. Jacquelyn G. Black (2013) Microbiology: Principles and Explorations, 6th Edition, John Wiley & Sons, Inc
15. Barnett, H. L. and Hunter, B. B. 1960. Illustrated Genera of Imperfect Fungi. Burgess Publishing Co., Minnesota.
16. Lodder J. (1974). The Yeasts: A Taxonomic Study, North Holland Publishing Co. Amsterdam.
17. Michael S. Rappe and Stephen J. Giovannoni (2003). The Uncultured Microbial Majority. Annual Review of Microbiology, 57: 369 – 94.
18. Rakesh Sharma, Ravi Ranjan, Raj Kishor Kapardar and Amit Grover (2005). 'Unculturavble' bacterial diversity: An untappedurrent Science, 89 resource. C(1)
19. Sonia R. Vartoukian, Richard M. Palmer and William G. Wade (2010). Strategies for culture of 'un-culturable' bacteria. Minireview, FEMS Microbiol Lett 309, 1 – 7.
20. James D. Oliver (2005). The Viable but Non-culturable State in Bacteria (2005). The Journal of Microbiology, 43, Special Issue, 93 – 100.
21. Anders Gorm Pedersen, Molecular Evolution: Lecture Notes, February 2005.
22. Lindell Bromham and David Penny (2003). The Modern Molecular Clock. www.nature.com/reviews/genetics. MARCH 2003 | VOLUME 4, Page. 216. Nature Publishing Group.
23. Lively Curtis, M. (1996). Host-parasite coevolution and sex. Bioscience 46, 2, 107.
24. Leo C. Vining (1992). Roles of secondary metabolites from microbes. Edited by Derek J. Chadwick, Julie. Whelm Copyright.

22-MBCT-112: Quantitative Biology

CO. No.	Course Outcomes
1.	Define and explain the fundamental concepts like variable, data, sample, population etc.
2.	Statistically analyze and measure central tendency & dispersion for the given/experimental data
3.	Present the data using appropriate method amongst frequency distribution table, Bar diagram, histogram, pie chart, scatter diagram etc
4.	Understand and apply the concepts of null hypothesis, Test statistics, P-value significance level, type I and type II errors, one tailed and two tailed tests, degrees of freedom, Parametric and nonparametric test
5.	Perform Test of Significance, ANOVA One way and two way, Post Hoc test, Sign test, Wilcoxon's signed rank test and Mann-Whitney U test, for the data provided.

Unit No.	Title and contents	No. of Lectures
1	**Descriptive Statistics** 1. Fundamental concepts –Sample Statistics and Population parameter, data (qualitative and quantitative data, discrete and continuous series data), data sources, variables, measurement scales (nominal, ordinal, interval and ratio), variability and uncertainty in measurements 2. Measures of central tendency – Mean, Mode, median 3. Measures of dispersion – Mean deviation Standard deviation and Variance 4. Data presentation-Tables and Graphs (Histogram, bar, pie and line) 5. Simple linear Regression and correlation (significance testing not necessary) (Sr. No. 1:- only theory questions to be asked in exam. Sr. No. 2 – 5:- only problem solving questions to be asked in exam.)	**(15)**

2	**Inferential Statistics-1** 1. Uncertainty: Variation, Probability and inference 2. Central Limit Theorem, Standard deviation of the means standard error and confidence interval 3. The concepts of null hypothesis, Test statistics, P-value significance level, type I and type II errors, one tailed and two tailed tests, degrees of freedom, Parametric and nonparametric test, statistical decision tree, Parametric statistical test: Z-test, t-test and F-test (Sr. No 1 – 3:- only theory questions to be asked in exam except Z-test, T-test and F-test.)	**(15)**
3	**Inferential Statistics-2** 1. Test of Significance: Chi square test (Goodness of fit and Independence), 2. Comparison of 3 or more samples – ANOVA One way and two way, Post Hoc test (Tukey's) 3. Nonparametric Tests: comparison to parametric tests, Sign test, Wilcoxon's signed rank test and Mann-Whitney U test	**(15)**
4	**Probability and Probability Distribution** 1. Concept of experiment, event (mutually exclusive & non-exclusive events, dependent & independent events) 2. Laws of probability (addition and multiplication); 3. Probability distribution – Normal (x-scale and z-scale), Binomial and Poisson distributions	**(15)**

Suggested References:

1. Irfan Ali Khan and AtiyaKhanum, Fundamentals of Biostatistics. 3rd Ed. Ukaaz, Publications, Hyderabad.

2. Bernard Rosner Fundamentals of Biostatistics,5th Ed. Duxbury Thomson

3. Wayne Daniel (2007) Biostatistics A foundation for Analysis in the health sciences,wileyIn

4. Lindgren B.W. Statistical Theory, Macmillan Publishing Co.Inc.

5. Norman T. J. Bailey Statistical methods in biology, 3rd Ed. Cambridge University Press

6. Gupta S.P. Statistical methods, Sultan Chand & Sons Publisher, New Delhi

7. Montgomery D.C. Design and analysis of experiments, John Wiley & Sons

8. Stephen Newman, Biostatistical methods in Epidemiology. Wiley Interscience Publication,

9. Aviva Petrie and Carolene Sabin (2005) Medical Statistics at a glance, 2nd Edition, Blackwell

10. Haefner James W. (1996) Modeling Biological Systems: Principles and Applications, Kluwer Academic Publications

11. David Brown & Peter Rothery. Models in biology: Mathematics, statistics, and computing John Wiley & Sons, USA

12. Practical Fermentation Technology Edited by Brian McNeil and Linda M. Harvey (2008) John Wiley & Sons, Ltd. ISBN: 978-0-470-01434-9

13. Bioprocess Engineering Principles by Pauline M. Doran (1995), Elsevier Science & Technology Books, ISBN: 0122208552

14. Peter J. Diggle, Amanda G. Chetwynd Statistics and Scientific Method: An Introduction for Students and Researchers, Publisher: Oxford University Press,

22-MBCT-113: Biochemistry and Metabolism	
CO. No.	**Course Outcomes**
1.	Describe structural features of amino acids, classify amino acids and explain their use as buffers, determination of primary structure of polypeptide, structural classification of proteins with specific examples.
2.	Solve problems on primary structure determination, use of amino acids as buffers and behavior of amino acids, peptides and proteins in solutions at different pH values and under effect of electric field
3.	Explain biochemistry and molecular biology techniques such as chromatography, electrophoresis, PCR reaction and sequencing of DNA and RNA.
4.	Explain structural aspects of carbohydrates, mechanism and regulations of carbohydrate metabolism
5.	Explain structure, function and nomenclature of fatty acids in lipids, role of lipids as structural component of cell membrane and as signaling molecules

Unit No.	Title and contents	No. of Lectures
1	**Protein Chemistry:** 1.Structural features of amino acids, classification of amino acids Amino acids as buffers, Henderson Hasselbalch equation and its role in buffer formulation 2. Peptide linkage, partial double bond nature of peptide bond Determination of primary structure of polypeptide (N-terminal, C-terminal determination, method of sequencing of peptides), 3. Structural classification of proteins: primary, secondary, tertiary, quaternary structures of proteins, Super-secondary structures- Motifs & Domains, Non-covalent interactions, Conformational properties of proteins, Polypeptide chain geometry, Resonance forms of the peptide group, cis/trans isomers of peptide group 4. Ramachandran plot 5. Structure and Functions of Myoglobin, Haemoglobin and Fibrous proteins	**(15)**
2	**Biochemistry and Molecular Biology Techniques** 1.Chromatography: Principles and applications of gel filtration, Ion exchange, affinity chromatography 2.Electrophoresis: Agarose, Native PAGE, SDS PAGE 3. Polymerase chain reaction: Principle, variations of PCR (Hot start, Nested, Reverse transcription, real time PCR) and its Applications. 4. Sequencing methods: RNA-sequencing methods and applications, DNA sequencing: Classical and next generation sequencing methods (Pyro-sequencing, Ion torrent, Nano-pore sequencing)	**(15)**
3	**Carbohydrate Chemistry and Metabolism** 1. Mono, di, oligosaccharides and polysaccharides, with examples 2. Isomerism in sugars: asymmetric centres in sugars, dextro, leavo-rotatory, sugar anomers (reducing and non-reducing sugars), sugar epimers 3. Sugar derivatives such as sugar alcohols, amino sugars, sugar acids, deoxy sugars 4. Glycolysis and gluconeogenesis, Regulation of glycolysis and gluconeogenesis, 5. Synthesis of microbial exopolysaccharides (alginate) 6. Cellulose synthesis and breakdown 7. Regulation of Glycogen synthesis; breakdown, 8. Metabolic flux and its regulation by various metabolic intermediates,	**(15)**

	9. TCA cycle- regulation, role in energy generation, Role in generating biosynthetic intermediates and glyoxylate cycle	
4	**Lipid Chemistry and Metabolism** 1. Classification of lipids according to chemical structure, 2. Fatty acids, saturated, unsaturated, branched, nomenclature system, 3. Structure and function of: triglycerides, phospholipids, sphingolipids, terpenes, prostaglandins, waxes, and steroids. 4. Synthesis of storage lipids: Fatty acids and triacylglycerols, 5. Synthesis of membrane lipids: Glycerophospholipids, sphingolipids, sterols, 6. Degradation of fatty acids (beta oxidation and unsaturated fatty acid) and fats in animals 7. Lipids as signal molecules (eg. phosphatidyl inositol, eicosanoids).	**(15)**

Suggested References:

1. Nelson D. L. and Cox M. M. (2002) Lehninger's Principles of Biochemistry, 4th edition, Mac Millan Worth Pub. Co. New Delhi.

2. Segel Irvin H. (1997). Biochemical Calculations. 2nd Ed. John Wiley and Sons, NY.

3. Garrett, R. H. and Grisham, C. M. (2004) Biochemistry. 3rd Ed. Brooks/Cole, Publishing Company, California.

4. Moat Albert G. and Foster John W. (2002) Microbial Physiology 4th Ed. John Wiley and Sons New York.

5. Donald Voet (Author), Judith G. Voet (2011). Biochemistry, 4th Edition, Kindle Edition

6. Berg Jeremy, Tymoczko John, Stryer Lubert (2002) *Biochemistry* 5th Ed, W. H. Freeman, New York.

7. Carl Ivar Branden, John Tooze (1999) Introduction to Protein Structure, 2nd Edition, Garland science.

22-MBCP-114: Biochemical Techniques (Core Compulsory Practical Paper)	
CO. No.	**Course Outcomes**
1.	Follow necessary safety rules while working in the laboratory and Do standardization of procedures, calibration and maintenance of the instruments and Design SOPs for the same
2.	Prepare and use stock solution and buffers of different types
3.	Use Microsoft excel for preparation of data sheets, handling experimental/ scientific data, presentation of data and statistical analysis of data.
4.	Enrich, isolate and identify extremophiles from various samples.
5.	Isolate and characterize lipase/cellulase/chitinases producing microorganisms
6.	Extract proteins and EPS from bacterial cultures and Estimate them using colorimetric and spectrophotometric methods
7.	Separate proteins using Chromatographic and electrophoretic technique
8.	Interpret Ramachandran plot for study of protein conformation

Sr.No.	**Contents**
1.	**S**afety rules in Laboratory: Laboratory safety, hazard from chemicals, handling of chemicals, disposal of chemicals and cultures, recording of scientific experiments. Standardization of laboratory procedures, calibration and validation instruments, preparing / designing SOP for the same, maintenance of instruments
2.	Buffer: Determination of pKa of a monoprotic weak organic acid; Preparation of buffers using $KH_2PO_4$and K_2HPO_4, acetic acid and sodium acetate, K_2HPO_4 and H_3PO_4.
3.	Computer applications: Using data sheets, and sorting data with different parameters, plotting graphs – bar charts, line graphs, pie charts, adding error bars. (Using Microsoft Excel) Statistical analysis of data – Students t test, ANOVA, Chi square test, F test using computer softwares (Using Microsoft Excel)

4.	Enrichment, Isolation and identification of the following extremophiles from natural samples: Alkaliphiles and Thermophiles. Identification 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.
5.	Isolation and characterization of lipase/ cellulose / chitinase producing microbe
6.	Extraction of Protein and Exo-polysaccharide from bacterial culture(may use TCA and ethanol method)
7.	Colorimetry and spectrophotometry: estimation of above sample: Bradford and UV Spectrophotometry (purity using A280 method).
8.	Chromatography: Separation of hydrolysed protein and EPS sample (above) using paper and thin layer chromatography. (Explain concept of two-dimensional chromatography and descending chromatography)
9.	Electrophoresis: SDS-PAGE of above proteins / To determine the ion-exchange capacity and nature of given resin using anion exchange chromatography
10.	Interpretation of Ramachandran Plot and study of conformations of protein molecule using Molecular Graphics Visualization Tool (e.g. Swiss PDB)

22-MBET-115: Fungal Systematics and Extremophiles
Choice based Optional Theory Paper (Elective)

CO. No.	Course Outcomes
1.	Students will be able to: Classify fungi based on their morphological characters.
2.	Explain characteristic features, enrichment and isolation of extremophiles.

Unit No.	Title and contents	No. of Lectures
1	**Fungal Systematics:** 1. Six Classes of Fungi 2. Differentiating characters among different Classes of fungi	**(15)**

	3. Importance of morphological characters in fungal differentiation and classification.	
2	**Extremophiles** 1.Enrichment, isolation, classification, properties and application of extremophiles: Thermophiles, Psychrophiles, Halophiles, Acidophiles, Methanogens 2. Adaptation mechanisms of extremophiles	**(15)**

22-MBEP-115: Practicals Based on Fungal Systematics and Extremophiles Choice based Optional Practical Paper (Elective)

CO. No.	Course Outcomes
1.	Students will be able to: Isolate and identify yeasts and fungi
2.	Isolate and identify extremophiles.

Sr.No.	Contents
1	Isolation and identification of yeasts and saprophytic molds from natural samples. The identification key must be designed for each isolated and identified fungus. Students are expected to isolate at least one Genus from Mold and Yeast each *(Varied types of samples should be processed to obtain representative isolate of the groups)*
2.	Isolation and identification of the following extremophiles from natural samples: Acidophiles and Halophiles Identification 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)*

22-MBET-116: Bioremediation and Biomass Utilization Choice based Optional Theory Paper (Elective)	
CO. No.	**Course Outcomes**
1.	Students will be able to: Explain Concept of bioremediation, different modes of bioremediation
2.	Describe use of genetic engineering technology to enhance bioremediation, plasmids useful in development of genetically engineered strains
3.	Explain conventional industrial processes of Alcohol, Fructose production and the improvements brought in to them
4.	Explain structure, arrangement and manipulation of Prokaryotic and eukaryotic cellulase genes

Unit No.	Title and contents	No. of Lectures
1	**Bioremediation** A. Microbial Degradation of xenobiotics, B. Engineered bio- degradative pathways: Camphor, octane, xylene, naphthalene degradation pathway C. Aromatic compound degradation: Manipulation by plasmid transfer Manipulation by gene alteration	(15)
2	**Biomass utilization** A. Utilization of starch and cellulose; B. Isolation of the prokaryotic and eukaryotic cellulase genes, manipulation of the cellulase gene, advantages of using *Zymomonas mobilis* C. Alcohol, fructose, and silage production; advantages of each D. Improvisation of the processes of alcohol production	(15)

Suggested References:

Bioremediation:

1. Glick B. R., Pasternak J. J., Cheryl L. and Patten C. L. (1998) Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington D C, ASM Press
2. Jaiswal S., Singh D. K. and Shukla P. (2019) Gene Editing and Systems Biology Tools for Pesticide Bioremediation: A Review. Front Microbiol. 10:87

3. Karpouzas D. G. and Singh B. K. (2006) Microbial degradation of organophosphorus xenobiotics: metabolic pathways and molecular basis. Adv Microb Physiol. 51:119-185.
4. .Ramos J. L., González-Pérez M. M. and Caballero A., van Dillewijn P. (2015) Bioremediation of polynitrated aromatic compounds: plants and microbes put up a fight. Curr Opin Biotechnol. 16(3): 275-281.
5. Weaver R. (2007) Molecular Biology. 4th Edition. Mc-Grew Hill Publication.

Biomass Utilization:

1. Glick B. R., Pasternak J. J., Cheryl L. and Patten C. L. (1998) Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington D C, ASM Press
2. Gupta G. V. (2016) New and Future Developments in Microbial Biotechnology and Bioengineering. *Aspergillus* System Properties and Applications. Elsevier Book Publication.
3. Lal P.B., Wells F.M., Lyu Y., Ghosh I.N., Landick R. and Kiley P.J. (2019) A markerless method for genome engineering in *Zymomonas mobilis* ZM4. Front.

22-MBEP-116: Practicals Based on Bioremediation and Biomass Utilization Choice based Optional Practical Paper (Elective)

CO. No.	Course Outcomes
1.	Students will be able to: Perform microbial degradation of pollutant compound and detect biodegradation activity using analytical techniques
2.	Carry out experiment for plastic degradation
3.	Explain methodology and applications of DNA fingerprinting technique
4.	Design and standardize process for production of biodiesel using algal mass
5.	Employ microbial biomass for removal of organic or inorganic chemicals such as Dyes, metal ions etc., from effluent samples.

Sr. No.	Contents
1	**Bioremediation** 1. Degradation of para nitrophenol using *Pseudomonas putida* 2. Low density plastic/bioplastic degradation using bacterial isolates 3. Demonstration of DNA finger-printing technique
2.	**Biomass utilization**

	1. Biodiesel production using micro-algae 2. Isolation of bio-emulsifier producing organisms for degradation of aromatic compounds

22-MBET-117: Nitrogen Metabolism, respiration and Photosynthesis Choice based Optional Theory Paper (Elective)	
CO. No.	**Course Outcomes**
1.	Students will be able to: Describe the process of nitrogen fixation, structure and regulation of nitrogenase enzyme, methods of ammonia assimilation observed in bacteria.
2.	Explain the biosynthesis of amino acids and nucleotides.
3.	Describe anaerobic respiration in nitrate, sulfate and carbonate reducing bacteria.
4.	Describe organization of photosystems, mechanism and regulation of photosynthesis C3, C4, CAM plants.

Unit No.	**Title and contents**	**No. of Lectures**
1	**Nitrogen Metabolism** 1. Biochemistry of biological nitrogen fixation, properties of nitrogenase and its regulation 2. Ammonia assimilation, glutamine synthetase, glutamate dehydrogenase, glutamate synthetase, their properties and regulation, 3. Biosynthesis of five families of amino acids and histidine, 4. Biosynthesis of purine and pyrimidine bases	(15)
2	**Respiration and photosynthesis** **1. Respiration:** Anaerobic Respiration: Concept of anaerobic respiration, oxidized sulfur compounds, and nitrate as electron acceptor with respect to electron transport chain and energy generation, Biochemistry of methanogens. 2. **Photosynthesis:** 1. Organization of photosystem I and II, cyclic and non-cyclic flow of electrons, Z scheme, Hill reaction, photolysis of water. 2. C3, C4 CAM plants, photorespiration, Regulation of photosynthesis	(15)

22-MBEP-117: Practicals Based on Nitrogen Metabolism, respiration and Photosynthesis Choice based Optional Practical Paper (Elective)	
CO. No.	**Course Outcomes**
1.	Students will be able to: Enrich and Isolate bacteria producing different plant growth promoting factors like IAA, Siderophores & fixing Nitrogen
2.	Detect IAA and Siderophores produced by bacteria using appropriate methods
3.	Extract and Estimate polyphenols & tannins by Folin-Denis method
4.	Enrich, Isolate and Characterize different groups of bacteria like Lignin degraders, sulphur reducing bacteria, Cyanobacteria
5.	Detect chlorophyll-a activity of cyanobacteria

Sr. No.	**Contents**
1.	Isolation of IAA producing organism, Detection of Indole acetic acid production by microorganism.
2.	Detection of siderophore production by microorganism
3.	Enrichment, Isolation and characterization of nitrogen fixing activity of bacteria
4.	Extraction and estimation of a) polyphenols, b) tannins by Folin Denis method
5.	Enrichment and isolation of lignin/xylan degraders from Soil
6.	Enrichment, Isolation and characterization of Sulphur reducing bacteria/ Methanogens
7.	Enrichment, Isolation and characterization of Cyanobacteria.
8.	Detection of chlorophyll-a activity of Cyanobacteria

SEMESTER II

22-MBCT-121: Instrumentation and Molecular Biophysics	
CO. No.	**Course Outcomes**
1.	Students will be able to: Explain biomolecular separation and detection by chromatography, electrophoresis and centrifugation
2.	Explain principles of operation, instrumentation of UV/Visible spectroscopy, Fluorescence spectroscopy, Infrared spectroscopy Circular Dichroism (CD) Mass spectroscopy
3.	Explain principles of operation, instrumentation of X-ray crystallography
4.	Explain principles of operation, instrumentation of NMR spectroscopy
5.	Explain the use of radioisotopes in biology
6.	Explain construction and working and applications of confocal microscope.

Unit No.	**Title and contents**	**No. of Lectures**
1	**Separation and analysis of biomolecules** 1.Techniques for sample preparation: Dialysis, ultra-filtration, centrifugal vacuum concentration 2a. Chromatography- Partition Coefficient, Selectivity, Resolution, Column Efficiency, Van Deemter equation, Interpretation of chromatograms 2b.Principle, instrumentation and applications of High Performance Liquid Chromatography (HPLC), Fast Protein Liquid Chromatography (FPLC), Supercritical Fluid Chromatography, Reversed Phase Chromatography and Gas chromatography. 3. Electrophoresis Methods: Pulse field gel electrophoresis, capillary electrophoresis, isoelectric focusing, 2-dimensional electrophoresis, immune-electrophoresis	(15)

2	**Spectroscopy** Introduction: Electromagnetic spectrum, Atomic orbitals, Molecular orbitals, Electronic, Rotational and Vibrational transitions in spectroscopy, Interpretation of spectra. 1. UV/Visible spectroscopy- Instrumentation, Molar Absorptivities, Beer and Lamberts Law, Bathochromic and hypochromic shifts. 2. Fluorescence spectroscopy- Instrumentation, Quantum Yield, Quenching, FRET, Binding and Folding studies, Flow cytometry and FACS 3. Infrared spectroscopy- Principle, Instrumentation, Absorption bands, FTIR and its applications 4.Mass spectroscopy- Principles of operation, Ionization, Ion fragmentation, Mass Analysers, GCMS, MALDI-TOF	(15)
3	**Biophysical Techniques** 1. NMR spectroscopy: Basic Principles of NMR, Chemical shift, Intensity, Line width, Relaxation parameters, Spin coupling, Nuclear Overhauser Effect Spectroscopy, Correlation Spectroscopy, Approach to structure determination by 2D-NMR 2. X-ray crystallography: Purification of proteins, Crystallization of proteins, Instrumentation, acquisition of the diffraction pattern, basic principles of x-ray diffraction, Crystal Structures (Bravais Lattices), Crystal planes and Miller Indices, Fourier Transform and Inverse Fourier, Direct Lattice and Reciprocal lattice, Ewald sphere, Electron density Maps, Phase determination	(15)
4	**Radioisotopes in Biology and Confocal Microscopy** 1. **Radioisotopes in Biology:** - Principles and applications of radio tracers in medicine, agriculture, industry, and fundamental research - Radiation and Radioactive isotopes: Types, Quantities and units of estimation, half-life of isotopes - Detection and measurement of radioactivity- Autoradiography, Liquid scintillation counting. - Effect of radiation on biological system **2. Confocal Microscopy:** scanning optical microscope, confocal principle, resolution and point spread function, light source: gas lasers & solid-state, primary beam splitter; beam scanning, pinhole and signal channel configurations, detectors; pixels and voxels; contrast, spatial sampling: temporal sampling: signal-to noise ratio, multichannel images	(15)

Suggested 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,* 3rd Ed. Prentice Hall, Pearson Education Limited, Harlow England.
4. Rodney F. Boyer (2000*) Modern Experimental Biochemistry*3d 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, AgnieszkaKraj (2009) *Mass spectrometry: instrumentation, interpretation, and applications*, John Wiley &Sons,Inc.,Canada.
8. Irwin H. Segel (1976) *Biochemical Calculations: How to SolveMathematical Problems in General Biochemistry,* 2nd Edition.John Wiley & Sons.
9. Mount, D. W. (2001) *Bioinformatics: sequence and genomeanalysis.* Cold Spring Harbor Laboratory Press, New York.
10. David M Webster (2000) *Protein Structure Prediction-Methods and Protocols*, Methods In Molecular Biology Vol143 Humana Press.
11. Narayanan, P. (2000) Essentials of Biophysics. New Age International Publication, New Delhi.
12. Christof M. Niemeyer and Chad A. Mirkin (2006) *Nanobiotechnology,* John Wiley & Sons.
13. Daniel L. Feldheim and Colby A. Foss, Jr. *(2002) Metal nanoparticles synthesis and characterization and applications* Marcel Dekker, Inc.
14. MahendraRai and Nelson Duran (2011) *Metal nanoparticles in Microbiology*, Springer Verlag Berlin Heidelberg.
15. Sohier, J., Laurent, C., Chevigné, A., Pardon, E., Srinivasan, V., Wernery, U. Galleni, M. (2013). Allosteric Inhibition of VIM Metallo-β-Lactamases by a Camelid Nanobody.Biochemical Journal, 450(3), 477-486. doi:10.1042/bj20121305.
16. Chakravarty, R., Goel, S., &Cai, W. (2014). Nanobody: The "Magic Bullet" for Molecular Imaging. Theranostics, 4(4), 386-398. doi:10.7150/thno.8006.

22-MBCT-122: Molecular Biology

CO. No.	Course Outcomes
1.	Students will be able to: Describe the details of the process of RNA processing in eukaryotes.
2.	Explain molecular techniques like Chromatin Immuno-precipitation (ChIP), Designing probe, Epitope tagging, expressed sequence tags.
3.	Explain how to construct cDNA and genomic libraries.

4.	Explain the importance of enzymes like klenow enzyme, T4 DNA polymerase and polynucleotide kinase in molecular techniques.
5.	Explain the use of vectors like M13, Pichia, Ti in cloning and gene expression.
6.	Describe the concept of genome project. Students will have learnt the genome projects of E. coli, yeast, Plasmodium, Mouse, Drosophila, Rice and human
7.	Describe the principle, working and applications of molecular diagnostic techniques like immunoassay, protein arrays.
8.	Explain various types of diagnostic techniques used for the detection of disease associated changes in gene expression, miRNA in cancers and RNA of antibiotic resistance in Bacteria.

Unit No.	Title and contents	No. of Lectures
1	**RNA processing & Molecular Techniques** 1. RNA Processing: Eukaryotic - mRNA splicing (Spliceosome and auto splicing by Intron I and Intron II), rRNAprocessing,tRNAprocessing, RNA Editing, -Nuclear export of mRNA - Regulatory RNAs and noncoding RNAs : Si RNA, Micro RNA, RNAi - Pi RNA (PIWI interacting RNAs) **2. Molecular Techniques** Knockout mice, phage display, expressed sequence tags, Yeast two and three hybrid assay, Activity gel assay, DNA helicase assay, Chromatin Immuno-precipitation (ChIP), Designing probe, Epitope tagging	(15)
2	**Tools for Genetic engineering** 1. Restriction endonucleases and methylases; DNA ligase, klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labeling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far western and colony hybridization, fluorescence in situ hybridization. 2. Vectors for cloning and gene expression: 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), Protein purification (His-tag, GST-tag, MBP-tag) 3. Construction of cDNA and genomic libraries	(15)

3	**Genome Projects** 1. Concept and meaning of genome projects and their applications 2. Introduction to Genome projects of E. coli, yeast, Plasmodium, Mouse, Drosophila, and Rice and comparative genomics 3. Gene annotation 4. Human Genome project and its applications	(15)
4	**Molecular diagnostics and applications** 1. Protein arrays to detect polygenic diseases, Immunoassay for protein confirmation-specific disorders 2. Detection of diseases-associated changes in gene expression using microarray 3. Detection of RNA signatures of Antibiotic Resistance in Bacteria 4. Detection of miRNA signatures of Cancer	(15)
	Suggested References 1. Benjamin Lewin. (2008) Genes IX, Jones and Bartelett Publishers Inc. 2. S.B Primrose and R M Twyman 2006 7th edition. Blackwell publishing 3. James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, 4. Michael Levine, Richard Loswick (2004) Molecular Biology of the Gene, 5th Edition, Pearson Education, Inc. 5. Molecular Biology of the Cell, Bruce Albert et. al., 6th Ed., Garland Sciences. 6. Molecular Biology, Loddish et. al., 7th Edn., W. H. Freeman, 2012 7. Weaver R., (2007) Molecular Biology, 4th Edition, McGrew Hill Science. 8. B. R. Glick, J.J. Pasterneck, Principles and applications of recombinant DNA, 3rd Ed., ASM press.	

22-MBCT-123: Cell organization and Biochemistry	
CO. No.	**Course Outcomes**
1.	Students will be able to: Describe Purifications of enzyme, purification chart.
2.	Describe kinetics of and derive kinetic equations for single substrate enzyme catalyzed reaction and two substrate enzyme catalyzed, reversible inhibitions and

	allosteric inhibition reactions, models of allosteric enzymes and examples of allosteric enzymes with their significance in allosteric regulation
3.	Calculate kinetic constants Km, Vmax and Ki, Gibbs free energy using provided data.
4.	Explain Laws of thermodynamics, and basic concepts in thermodynamics
5.	Explain basic concepts of developmental biology such as commitment, determination, differentiation, pattern formation in body axis, Hox code, MPF.
6.	Describe morphogen gradients in developmental regulation, steps of embryogenesis in *Drosophila* and *Xenopus* model systems, morphogenesis and organogenesis in plants.
7.	Describe organization and function of eukaryotic cell organelles and protein trafficking among various cellular compartments, cell cycle and its regulation, mechanism and significance of apoptosis.

Unit No.	Title and contents	No. of Lectures
1	**Enzymology** 1.Purifications of enzyme, purification chart, 2. Kinetics of reversible inhibitions: Competitive, uncompetitive, non-competitive, mixed, substrate. Primary and secondary plots, Determination of Ki using secondary plots. Significance of inhibitors 3.King Altman approach to derive – two substrate enzyme catalysed reactions 4.Concept of allosterism, positive and negative co-operativity, models of allosteric enzymes (Monad, Wyamann and Changuax and Koshland, Nemethy and Filmer model), kinetics of allosteric enzyme, Hill plot, examples of allosteric enzymes and their significance in regulation.	(15)

2	**Bioenergetics** 1. Laws of thermodynamics, entropy, enthalpy, free energy, free energy and equilibrium constant Gibbs free energy equation with reference to biological significance. 2. Determination of free energy of hydrolytic and biological oxidation reduction reactions under standard and non-standard conditions 3. High energy compounds 4. Coupled reactions 5. Determination of feasibility of reactions 6. Problems based on 2 and 4. 7. Atkinson's energy charge.	(15)
3	**Cell biology** 1. Structural organization and function of Endoplasmic Reticulum, Golgi apparatus, Nucleus, Mitochondrion, chloroplast, Lysosomes, peroxisomes; Cytoskeleton and function of Molecular motors. 2. Protein trafficking among various cellular compartments (by secretory and cytosolic pathway: targeting to secretory vesicles, cell membrane, lysosomes, nucleus, mitochondria and peroxisomes) 3. Events in cell cycle, Regulation of cell cycle. Apoptosis	(15)
4	**Developmental Biology:** 1. Introduction to developmental biology. 2. Different model systems used to study developmental biology Conserved nature of development, Concepts of commitment, determination and differentiation 3. Morphogen gradients in developmental regulation, Hox code, MPF 4. Gastrulation and cellular movements involved in it, Organizer and its importance giving examples of invertebrates (Drosophilla) and vertebrate (Xenopus) model systems, pattern formation in body axis, antero-posterior and dorso-ventral polarity. 5. Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem; shoot and root development; transition to flowering, floral meristems and floral development in Arabidopsis.	(15)

Suggested References:

1. Nelson D. L. and Cox M. M. (2005) Lehninger's Principles of Biochemistry, Fourth edition, W.H. Freeman & Co. New York.
2. Palmer Trevor (2001) Enzymes: Biochemistry, Biotechnology and Clinical chemistry, Horwood Pub. Co. Chinchester, England.
3. Segel Irvin H. (1997) Biochemical Calculations 2nd Ed., John Wiley and Sons, New York
4. Garrett, R. H. and Grisham, C. M. (2004) Biochemistry. 3rd Ed. Brooks/Cole, Publishing Company, California
5. Michael T. Madigan, John M. Martinko, David A. Stahl, David P. Clark (2012) Brock Biology of Microorganisms, Thirteenth edition, Benjamin Cummings, San Francisco.
6. Moat Albert G. and Foster John W. (1988) Microbial Physiology 2nd Ed. John Wiley
7. Berg Jeremy, Tymoczko John, StryerLubert (2001) Biochemistry 4th Ed, W. H. Freeman, NY
8. 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

Cell Biology

1. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. (2002) Molecular Biology of the Cell, 4th edition,: Garland Science; New York
2. Metzler David E. (2001) Biochemistry: The chemical Reactions of Living Cells, Volume 1&2, Academic Press California.
3. H. Lodish, A. Berk, C. A. Kaiser, M. Krieger, M. P. Scott, A. Bretscher, H. Ploegh, and P. Matsudaira, (2007) Molecular Cell Biology, Sixth Edition W. H. Freeman and Company, New York, , ISBN-13: 978-0-716-77601-7

Development and Differentiation

1. Gilbert Scott F. (2010). Developmental Biology. 9th Ed. Sinauer Associates Inc. Mass. USA.
2. Muller W.A. (1997) Developmental Biology, SpringlerVerlag, New York, Inc.
3. Lewis Wolpert, Cheryll Tickle, and Alfonso Martinez

22-MBCP-124: Practical based on Molecular biology, enzymology and instrumentation Techniques

CO no.	Course Outcomes
1.	Students will be able to: Design an experiment to study induction of beta galactosidase enzyme by lactose using colorimetric method and through diauxic growth curve
2.	Isolate, Quantify, Characterize and Cure plasmid from bacterial cells

3.	Use various online and off-line tools to annotate genes
4.	Purify enzyme and Determine kinetic parameters for the same.
5.	Determine molar extinction coefficients of various biomolecules
6.	Isolate Aflatoxin producing organism and extract & detect the same from food samples.
7.	Learn the role of chemical treatments in the procedure to study mitosis and to observe the stages of mitosis and polyploidy in onion root tips.
8.	Develop scientific communication and writing skills.

Sr. No.	**Contents**
1.	Concept of lac-operon: Lactose induction of Beta galactosidase; Glucose Repression; Diauxic growth curve of E. coli
2.	Plasmid DNA isolation, DNA quantitation and characterization by gel electrophoresis.
3.	Construction of restriction digestion map of plasmid DNA
4.	Curing of bacterial Plasmid
5.	Gene annotation
6.	Purification of enzymes (Amylase/Invertase): (ammonium sulphate precipitation, organic solvent precipitation, gel filtration, etc.) (Any two Methods)Establishment of enzyme purification chart
7.	Determination of Km, Vmax and Kcat values of enzyme
8.	Determination of molecular extinction coefficient of biomolecule
9.	Isolation of Aflatoxin producing organism. Extraction and Detection of Aflatoxin in food
10.	Studying the stages mitosis in growing tip of onion root cells and to observe polyploidy induced by colchicine treatment on root tip.
11.	Demonstration of mounting of embryos (frog and fruit fly) at various developmental stages on permanent slides

12.	Scientific Communication and Research Methodology Concept of effective communication: Presentation skills, formal scientific presentation skills; Preparing power point presentation, Presenting the work, Scientific poster preparation &oral presentation; Participating in group discussions. Technical writing skills: Types, Formats of scientific reports , scientific writing skills, Significance of communicating science, ethical issues, copyrights and plagiarism, Components of a research paper, publishing scientific papers - peer review process and problems. Use of search engines for scientific data mining, use of reference, use of reference management tools (e.g.Zotero)
13.	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)
14.	Visit to any lab or institute to understand the principle and working of the bio-analytical instrument studied in theory courses(optional)

22-MBET-125: Bioinformatics and Bio-nanotechnology
Choice based Optional Theory Paper (Elective)

CO. No.	Course Outcomes
1.	students will be able to: Explain various biological databases for Nucleic acid, proteins, genomes, structure databases, search engines, sequence data forms and submission tools
2.	Explain Synthesis and applications of nanoparticles,
3.	Explain Characterization of nanoparticles and Significance of their physical properties
4.	Explain about Magnetotactic bacteria for natural synthesis of magnetic nanoparticles

Unit No.	Title and contents	No. of Lectures

1	**Bioinformatics** 1. Introduction and biological databases Nucleic acid, proteins, genomes— structure data bases, search engines, sequence data forms and submission tools, scoring matrices for sequence alignments, algorithms pairwise sequence alignments, database similarity searches-BLAST, FASTA 2. Gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques, Multiple sequence alignment, phylogenetic analysis and tree building methods, motif searches, epitope prediction, data mining tools and applications, promoter and gene prediction, comparative analysis 3. Demonstration of databases (GENBANK, PDB, OMIM) and software (RASMOL, Ligand Explorer)	(15)
2	**Techniques in Bio-nanotechnology** 1. Biogenic nanoparticles – Synthesis and applications. Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Role of plants in nanoparticle synthesis. 2. Significance of the physical properties of nanoparticles 3. Characterization of nanoparticles Dynamic Light Scattering (DLS), EDAX analysis, Zeta analysis 4. Imaging techniques to characterize nanoparticles: Principle, instrumentation and applications of - TEM (Transmission Electron Microscope) - SEM (Scanning Electron Microscope) - Scanning Probe Microscopy (SPM) - AFM (Atomic Force Microscopy)	(15)

22-MBEP-125: Practicals Based on Bioinformatics and Bio-nanotechnology
Choice based Optional Practical Paper(Elective)

CO No.	Course Outcomes
1.	Students should be able to: Explain various biological databases for Nucleic acid, proteins, genomes, structure databases, search engines, sequence data forms and submission tools
2.	Explain Synthesis and applications of nanoparticles,

3.	Explain Characterization of nanoparticles and Significance of their physical properties
4.	Explain about Magnetotactic bacteria for natural synthesis of magnetic nanoparticles

Sr. No.	Contents
1.	**Bioinformatics** 16S rRNA gene sequencing analysis of bacteria: -Isolation, purity checking using A_{260}/A_{280} ratio and Agarose gel electrophoresis of isolated chromosomal DNA of bacteria -PCR amplification and purification of 16S rRNA gene -Demonstration of the following steps, if not possible to perform in your lab: PCR product Sequencing using automated sequencer -Sequence matching by BLAST analysis. -Drawing phylogenetic tree using related sequences (Using standard software like Phylip, Mega etc
2.	**Bionanotechnology** 1.Biological synthesis of nanoparticles (at least 2 types) using actinomycetes /fungi /yeast and their characterization by UV-Vis spectroscopy Characterisation of nanoparticles, Antimicrobial activity, dye decolorization activity, etc 2. Biological synthesis of nanoparticles (at least 2 types) using plant material/plant extract - Extract preparation - Synthesis of nanoparticles - characterization by UV-Vis spectroscopy - Characterization of nanoparticles, Antimicrobial activity, dye decolorization activity, etc 3. Nanoparticle characterization data analysis(data to be obtained from scientific literature) - SEM/TEM/AFM images,FTIR scan, DLS,zeta potential, etc.

22-MBET-126: Molecular Biology tools and applications
Choice based Optional Theory Paper (Elective)

CO. No.	Course Outcomes
1.	Students should be able to Explain protein-DNA interactions, various assays on electrophoretic mobility shift, methyl interference assay
2.	Explain DNA microarray, Construction of microarrays and other genomic arrays
3.	Explain application of RDT in Production of Secondary Metabolites

4.	Explain use of RDT in Hybrid Human-Mouse monoclonal antibodies, Human monoclonal antibodies, anticancer antibodies

Unit No.	Title and contents	No. of Lectures
1	**Tools in Molecular Biology** 1. Study of protein-DNA interactions: electrophoretic mobility shift assay; DMS foot printing, DNase foot printing; methyl interference assay, protein-protein interactions using yeast two-hybrid system; phage display. 2. DNA microarray, Construction of microarrays – genomic arrays, cDNA arrays and oligo arrays 3. Super shift assay and EMSA, Sequence tagged sites, Filter binding assay, Protein foot-printing, finding the replicon, DNA fingerprinting, Measuring transcription rates 4. Hybridization techniques: Free solution, membrane based (DOT blot, SLOT blot), Fluorescence in situ hybridization (FISH) and Microarray technology, 5. CRISPR-Cas system: Technology and Applications	(15)
2	**Applications of recombinant DNA technology–** Application of RDT in Production of Secondary Metabolites 1. Synthesis of commercial products: Amino acids (L- Valine and L-cysteine), ascorbic acid, Polyketide antibiotics, 2. Hybrid Human-Mouse monoclonal antibodies, Human monoclonal antibodies, anticancer antibodies 3. Bio-polymers: gum, rubber, poly-hydroxy alkanoates. 4. Un-conventional microbial systems for production of high-quality protein drugs.	(15)

22-MBEP-126: Practicals Based on Molecular Biology tools and applications Choice based Optional Practical Paper (Elective)

CO. No.	Course Outcomes
1.	Students should be able to Explain cloning vectors, transformation, transformation efficiency
2.	Explain PCR technique, PCR primer designing

Sr. No.	Contents
1.	Cloning and transformation using plasmid vectors- GFP gene cloning /blue and white screening - Vector and Insert Ligation, - Preparation of competent cells - Transformation of *E. coli* with standard plasmids, - Calculation of transformation efficiency
2.	PCR amplification and purification of 16S rRNA gene
3.	PCR Primer Design
4.	Protoplast fusion
5.	Activity staining analysis (Zymograms) (NATIVE PAGE)
6.	FTIR analysis of a biomolecule/recombinant molecule (at least five different molecules)
7.	Production by recombinant strain and estimation of Biopolymers: a) Gum b) Polyhydroxyalkanoates (PHB)

22-MBET-127: Microbial communication, Membrane transport and signal transduction Choice based Optional Theory Paper(Elective)	
CO. No.	**Course Outcomes**
1.	students will be able to: Describe Life cycle of *Dyctiostellium discoideum* and myxobacteria.
2.	Explain molecular mechanism of quorum sensing in slime moulds, myxobacteria and specific examples of gram positive and gram negative bacteria
3.	Describe biofilms formation and dispersal, significance of biofilms in pathogenic and nonpathogenic environments.

4.	Describe the composition and architecture of membranes, membrane dynamics, structure and significance of liposomes and model membranes, various modes of solute transport across membranes
5.	Explain signal transduction and mechanism of chemotaxis.

Unit No.	Title and contents	No. of Lectures
1	**Communication and Coordination among microorganisms** 1.Life cycle of *Dictyostelium discoideum,* Molecular mechanism of quorum sensing in slime moulds, 2. Life cycle of myxobacteria, Molecular mechanism of quorum sensing in myxobacteria. 3. Quorum sensing in Gram positive and Gram-negative bacteria, 4. Biofilms, their organization, signals involved in their formation and dispersal, 5. Applications of study on biofilms in pathogenic and non-pathogenic environments	**15**
2	**Membrane transport and signal transduction** 1.The composition and architecture of membranes, Membrane dynamics, 2. Solute transport across membranes: Passive diffusion, facilitated transport, primary and secondary active transport using P, V and F type ATPases, Ionophores, 3. Ion mediated transport, transport of ions across membranes (ion pumps), ligand and voltage gated ion channels, 4. Liposomes and model membranes, 5. Signal transduction pathways in bacteria, second messengers, regulation of signalling pathways, bacterial two-component systems, chemo taxis.	**15**

Suggested References

Communication and Coordination among microorganisms

1. Gilbert Scott F. (2010). Developmental Biology. 9th Ed. Sinauer Associates Inc. Mass. USA.
2. Martin Dworkin (1996) Recent advances in the social and developmental biology of the myxobacteria, Microbiological Reviews, , p. 70–102
3. Dale Kaiser, Mark Robinson and Lee Kroos (2010) Myxobacteria, Polarity, and Multicellular Morphogenesis, Cold Spring HarbPerspectBiol 2010;2:a000380
4. Toole 'O' George, H. B. Kaplan, R. Kolter,(2000) Biofilm formation as microbial development Annual Review of Microbiology, Vol. 54, 49-79 4.
5. Melissa B. Miller and Bonnie L. Bassler (2001) Quorum sensing in bacteria. Annu. Rev. Microbiol. Vol. 55, 165–99.
6. Christopher M. Waters and Bonnie L. Bassler (2005) Quorum sensing: cell-to-cell communication in bacteria. Annu. Rev. Cell Dev. Biol. Vol. 21, 319–46.

22-MBEP-127: Practicals Based on Microbial communication, Membrane transport and signal transduction
Choice based Optional Theory Paper (Elective)

CO. No.	Course Outcomes
1.	students will be able to: Study and estimate development of biofilm
2.	Design an experiment to study the mechanism of quorum sensing in bacteria.
3.	Perform various methods to study chemotactic response of bacteria to various chemical stimuli
4.	Carry out cell disruption using different methods
5.	Explain and study the principle of osmosis and diffusion with the help of artificial

	membranes

Sr. No.	Contents
1.	**Communication And Coordination among microorganisms** Crystal violet assay for estimation of biofilm formation
2.	Bioassay for determination of quorum sensing signals produced by bacteria.
3.	Determination of chemo-taxis responses shown by bacteria using agar plate or capillary tube method. Membrane transport and signal transduction
4.	Study principles of osmosis and diffusion using artificial membranes (dialysis membrane) (explain how various physical and chemical factors affect the diffusion)
5.	Different methods of cell disruption.

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