Maharashtra Education Society's Abasaheb Garware College

(Autonomous)

(Affiliated to Savitribai Phule Pune University, Pune)

Syllabus

Two Year M.Sc. Degree Program in Microbiology

(Faculty of Science and Technology)

Syllabi under Autonomy
M.Sc. 1 (Microbiology)

Choice Based Credit System Syllabus

To be implemented from Academic Year 2022-23

Title of the Course: M.Sc. (Microbiology)

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, 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.

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 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. Thus, the university / college itself will be developing the trained and skilled manpower. We are restructuring the syllabus in

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

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

3. Program outcome:

- 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 awareness
- To help students build-up a progressive and successful career in Microbiology

4. Eligibility: Minimum 50% marks at B.Sc. (45% marks for reserved category). For students of Savitribai Phule Pune University (SPPU): B.Sc. with Microbiology as principle subject. For students from other than SPPU with general B.Sc.: one of the subject should be Microbiology at T.Y.B.Sc. As per rules and regulations of SPPU.

5. Course Structure and assessment of credits:

I. Total credits:

A full master's degree course in Sciences would be of 80 credits. One credit course of theory will be of one clock hour per week, running for 15 weeks and one credit for practical course will consist of 30 clock hours of laboratory exercises. There shall be four semesters and credits are distributed over 4 semesters. There will be 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.

Structure of the course (M.Sc. Microbiology):

Year	Semester	Course type	Course code	Course title	Credits	No. of lectures / practicals to be conducted
1	1	Compulsory Theory papers	PSMR-111	Microbial Systematics	4	60
			PSMR-112	Quantitative Biology	4	60
			PSMR-113	Biochemistry and Metabolism	4	60
		Compulsory Practical	PSMRP-114	Biochemical Techniques (Practical based on compulsory theory credits)	4	120
		Choice Based Optional papers	PSMRELE-115A	Fungal Systematics and Bacterial Extremophiles	2	30
			PSMRPELE-115A	Practicals Based on Fungal Systematics and Bacterial Extremophiles	2	60
				OR		
			PSMRELE-116B	Experimental Design and Quantitative approaches for Biologist	2	30
			PSMRPELE-116B	Practical based on Experimental Design and Quantitative approaches for Biologist	2	60
				OR		
			PSMRELE-117C	Microbial communication, Membrane transport and signal transduction	2	30
			PSMRPELE-117C	Practicals Based on Microbial communication, Membrane transport and signal Transduction	2	60

Year	Semester	Course type	Course code	Course title	Credits	No. of lectures / practicals to be conducted
1	2	Compulsory Theory papers	PSMR-121	Instrumentation and Molecular Biophysics	4	60
			PSMR-122	Molecular Biology	4	60
			PSMR-123	Enzymology, Bioenergetics and Metabolism	4	60
		Compulsory Practical	PSMRP-124	Molecular biology, Enzymology and Instrumentation Techniques (Practical basedon compulsory theory credits)	4	120
		Choice Based Optional Papers	PSMRELE-125A	Bioinformatics and Bio-nanotechnology	2	30
			PSMRPELE-125A	Practicals based on Bioinformatics and Bio-nanotechnology	2	60
				OR		
			PSMRELE-126B	Molecular Biology tools and applications	2	30
			PSMRPELE-126B	Practical based on Molecular Biology tools and applications	2	60
				OR		
			PSMRELE-127C	Nitrogen Metabolism, Respiration and Photosynthesis	2	30
			PSMRPELE-127C	Practicals Based on Nitrogen Metabolism, Respiration and Photosynthesis	2	60

Year	Semester	Course Type	Course Code	Course Title	Credits	No. of lectures / practicals to be conducted
2	III	Compulsory Theory papers	PSMR-231	Immunology	4	60
			PSMR-232	Molecular Biology	4	60
			PSMR-233	Clinical Microbiology	4	60
		Compulsory Practical	PSMRP-234	Practicals based on Compulsory Theory Credits.	4	120
		Choice Based Optional Papers		OR		
			PSMRELE-231A	Cell Culture Techniques	2	30
			PSMRPELE-231A	Practical based on Cell Culture Techniques	2	60
				OR		
			PSMRELE-232B	Bioremediation and Biomass utilization	2	30
			PSMRPELE-232B	Practical based on Bioremediation and Biomass utilization	2	60
				OR		
			PSMRELE-233C	Microbial Virus Technology	2	30
			PSMRPELE-233C	Practical based on Microbial Virus Technology	2	60

Year	Semester	Course Type	Course Code	Course Name		
2	IV	Compulsory Theory Papers	PSMR-241	Pharmaceutical Microbiology	4	60
			PSMR-242	Microbial Technology	4	60

		Compulsory Practical	PSMRP-243	Dissertation	4	120
		Choice Based Optional Papers (ANY TWO)		OR		
			PSMRELE-241A	Quality Assurance and Validation in Pharmaceutical Industry and Development of Anti Infectives	2	30
			PSMRPELE-241A	Practicals based on Quality Assurance and Validation in Pharmaceutical Industry and Development of Anti Infectives	2	60
				OR		
			PSMRELE-242B	Advances in Microbial Technology	2	30
			PSMRPELE-242B	Practicals based on Advances in Microbial Technology	2	60
				OR		
			PSMRELE-243C	Industrial Waste Water Treatment and Industrial Production of Vaccines	2	30
			PSMRPELE-243C	Practicals based on Industrial Waste Water Treatment and Industrial Production of Vaccines	2	60
				OR		
			PSMRELE-244D	Bioethics, Biosafety, Quality Control and Quality Assurance	2	30
			PSMRPELE-244D	Practicals based on Bioethics, Biosafety, Quality Control and Quality Assurance	2	60

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

Course Type	Course Code		Course Name	Credit	Assessment		
					IA	UE	Total
Core Compulsory Theory Papers	PSMR-111		Microbial Systematics	4	30	70	100
	PSMR-112		Quantitative Biology	4	30	70	100
	PSMR-113		Biochemistry and Metabolism	4	30	70	100
Core Compulsory Practical paper	PSMRP-114		Biochemical Techniques (Practical based on compulsory theory credits)	4	30	70	100
Choice Based Optional Papers Elective/ Departmental Course **Any one group**	Group I	PSMREL E-115A	Fungal Systematics and Bacterial Extremophiles	2	15	35	50
		PSMREL EP-115A	Practicals Based on Fungal Systematics and Bacterial Extremophiles	2	15	35	50
	OR						
	Group II	PSMREL E-116B	Experimental Design and Quantitative approaches for Biologist	2	15	35	50
		PSMREL EP-116B	Experimental Design and Quantitative approaches for Biologist	2	15	35	50
	OR						
	Group III	PSMREL E-117C	Microbial communication, Membrane transport and signal transduction	2	15	35	50
		PSMREL EP-117C	Practicals Based on Microbial communication, Membrane transport and signal Transduction	2	15	35	50

MR: Microbiology; ELE: Elective

III. B) M. Sc. First year Microbiology Semester II assessment of credits

Course Type	Course Code		Course Name	Credit	Assessment		
					IA	UE	Total
Core Compulsory Theory Papers	PSMR-121		Instrumentation and Molecular Biophysics	4	30	70	100
	PSMR-122		Molecular Biology	4	30	70	100
	PSMR-123		Enzymology, Bioenergetics and Metabolism	4	30	70	100
Core Compulsory Practical paper	PSMRP-124		Molecular biology, Enzymology and Instrumentation Techniques (Practical based on compulsory theory credits)	4	30	70	100
Choice Based Optional Papers Elective/ Departmental Course **Any one group**	Group I	PSMRELE-125A	Bioinformatics and Bio-nanotechnology	2	15	35	50
		PSMRELEP-125A	Practicals based on Bioinformatics and Bio-nanotechnology	2	15	35	50
	OR						
	Group II	PSMRELE-126B	Molecular Biology tools and applications	2	15	35	50
		PSMRELEP-126B	Practical based on Molecular Biology tools and applications	2	15	35	50
	OR						
	Group III	PSMRELE-127C	Nitrogen Metabolism, Respiration and Photosynthesis	2	15	35	50
		PSMRELEP-127C	Practicals Based on Nitrogen Metabolism, Respiration and Photosynthesis	2	15	35	50

IV. Course Evaluation:

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

V. Examination Results:

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

VI.The GPA:

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

VII.Rules and University Guidelines:

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

VIII. Important Note:

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

5.General Instructions:

The post-graduate degree will be awarded to students who obtain a total 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 and

b) End-semester assessment.

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

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

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

nature of questions for the unit test. Semester end examination for remaining 70% marks will be conducted by MES Abasaheb Garware College. 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 principle 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 5^{th} / 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.

M. Sc. Microbiology First Year Semester I syllabus

	Semester I	
Credits	**PSMR-111:Microbial Systematics** Core Compulsory Theory Paper Total: 4 Credits; Workload: -15 hrs /credit (Total Workload: - 4 credits x 15 hrs = 60 hrs in semester) **Course outcome:** **1.** To gain knowledge of systematics of bacteria **2.** To understand Evolutionary aspect of development **3.** To learn different approaches bacterial systematics	**Lectures**
Credit I	**Bacterial Systematics** 1. Species concept in prokaryotes and eukaryotes 2. Speciation concept 3. 5-Kingdom classification system 4. 3-Domain classification system 5. Determinative Bacteriology (Phenetic Approach) 6. Systematic Bacteriology (Phylogenetic Approach) 7. Polyphasic Approach 8. Molecular clocks, phylogeny and molecular distances	**15**
Credit II	**Microbial Diversity** 1. Facets of microbial diversity: morphological, structural, metabolic, ecological, behavioral and evolutionary 2. Factors affecting species divergence 3. Measurement of microbial diversity 4. Measures and indices of diversity; alpha, beta and gamma diversity	**15**
Credit III	**Exploration of Un-culturable microbial diversity:** 1. Concept of 'unculturable' bacterial diversity 2. Culture independent molecular methods for identifying unculturable bacteria (PCR, RFLP, ARDRA, DGGE, TGGE, RAPD, Microarray, FISH, RISA) 3. Strategies for exploring 'unculturable' bacteria 4. Metagenomic (methods and data analysis)	**15**
Credit IV	**Evolution** 1. History and development of evolutionary theory (Lamarckism, Darwinism), Neo Darwinism: Spontaneous mutation controversy, evolution of rates of mutation, types of selection, levels of selection, group selection and	**15**

	selfish gene. 2. Socio-biology, kin selection, evolutionary stability of cooperation, sociality and multi- cellularity in microorganisms, Game theory. Co-evolutionary strategies, host parasite co- evolution 3. Molecular evolution: origin of life, the origin of new genes and proteins ageing, evolutionary trade-offs, r and k Selection	

Suggested References: PSMR-111: Microbial Systematic [Semester I]

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, Inc
3. Bromham L. and Penny D. (2003). The Modern Molecular Clock. Nat Rev Genet. 4(3): 216-224. Nature Publishing Group.
4. Brown J. (2014). Principles of Microbial Diversity. ASM Press.
5. Buchanan, R. E. and Gibbons, N. E. (editors). 1974. Bergey's Manual of Determinative Bacteriology. 8th ed. Williams & Wilkins Co., Baltimore
6. 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 NewYork
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 A: The Gamma proteobacteria. 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: The Proteobacteria. Part B: Alpha proteobacteria. 2nd Edition. Springer-Verlag US
9. 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
10. Keller M. and Zengler K. (2004) Tapping in to Microbial Diversity. Nature Reviews. 2(2):141-150
11. 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.
12. 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 NewYork
13. 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
14. Lodder J. (1974). The Yeasts: A Taxonomic Study. North Holland Publishing Co. Amsterdam.
15. Lozupone C. A. and Knight R. (2008). Species Divergence and the measurement of microbial diversity. FEMS Microbiol. Rev. 32: 557 –578.
16. Ogunseitan O. (2008). Microbial Diversity: Form and Function in Prokaryotes. Published Online: 30 November 2007. DOI: 10.1002/9780470750490. Copyright © 2005 by Blackwell Science Ltd
17. Oliver J. D. (2005). The Viable but Non-culturable State in Bacteria (2005). The Journal of Microbiology. 43: 93 –100.
18. Pace N. (1997). A Molecular View of Microbial Diversity and the Biosphere. Science. 276: 734-740.
19. Pedersen A. G. Molecular Evolution: Lecture Notes. February 2005.http://www.cbs.dtu.dk/dtucourse/cookbooks/gorm/27615/lecturenotebook.pdf
20. Rappe M. S. and Giovannoni S. J. (2003). The Uncultured Microbial Majority. Annual Review of Microbiology. 57: 369 –394.
21. Ridley M. (2004). Evolution. Blackwell Science Ltd.
22. Sharma R., Ranjan R., Kapardar R. K. and Grover A. (2005). 'Unculturable' bacterial diversity: An untapped resource. Current Science. 89 (1):72-77
23. StaleyJ. T., Holt J. G., Bergey D. H., Bergey D. H., Williams S. T., Sneath P. H. A., Krieg N. R. and Holt J. G. (1994). Bergey's Manual of Determinative Bacteriology. Hong Kong: Williams &Wilkins.
24. Sykes, G. and F. A. Skinner (Eds). Actinomycetales: Characteristics and Practical Importance. Society for Applied Bacteriology Symposium Series No. 2, Academic Press. 1973.
25. Vartoukian S. R., Palmer R. M. and Wade W. G. (2010). Strategies for culture of 'un-culturable' bacteria. Minireview. FEMS Microbiol Lett. 309:1 –7.
26. Vining L. C. (1992) Roles of secondary metabolites from microbes. Ciba Found Symp. 171:184-194. discussion 195-8. doi: 10.1002/9780470514344.ch11. PMID:1302177.
27. Vos P., Garrity G., Jones D., Krieg N. R., Ludwig W., Rainey F. A., Schleifer K. and William Whitman. (2005). Bergey's Manual of Systematic Bacteriology. Volume 3: The Firmicutes. 2nd Edition. Springer-VerlagUS
28. Whitman W., Goodfellow M., Kämpfer P., Busse H.-J., Trujillo M., Ludwig W., Suzuki K.-I. and Parte A. (Editors). (2012). Bergey's Manual of Systematic Bacteriology. Volume 5: The Actinobacteria. 2nd Edition. Springer-Verlag NewYork
29. Woese C. (1987). Bacterial Evolution. Microbiological Reviews.221-271.
30. Woese C. R. (2004). The archaeal concept and the world it lives in: a retrospective. Photosynthesis Research 80: 361 – 372. Kluver Academic Publishers.

	Semester I	
Credits	**PSMR-112: Quantitative Biology** Core Compulsory Theory Paper Total: 4 Credits Workload: -15 hrs /credit (Total Workload: - 4 credits x15 hrs = 60 hrs in semester) **Course outcome :** 1. To gain concepts of different methods in statistics 2. To understand different analytical methods 3. To learn different approaches quantitative biology	**Lectures**
Credit I	**Descriptive Statistics** 1. Basic concept in statistics: Sample Statistics, Population parameter, variables, Sampling methods, Types of data (qualitative and quantitative data, discrete and continuous series data), Sources of data, measurement scales (nominal, ordinal, interval and ratio), variability and uncertainty in measurements 2. Measures of central tendency : Mean, Mode and 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	**15**
Credit II	**Inferential Statistics-I** 1. Uncertainty: Variation, Probability and inference 2. Central Limit Theorem, Standard deviation of the means standard error and confidence interval 3. Basic concepts: Null hypothesis, P-value significance level, Test statistics, type I and type II errors, one tailed and two tailed tests, degrees of freedom. 4. Importance of Parametric and nonparametric tests 5. Parametric statistical test:Z-test, t-test and F-test	**15**
Credit III	**Inferential Statistics-II** 1. Test of Significance: Chi square test (Goodness of fit and Independence) 2. ANOVA : One way and two- way, Post Hoc test(Tukey's) 3. Non-parametric Tests: Sign test, Wilcoxon's signed rank test and Mann-Whitney U test	**15**

Credit IV	**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 for PSMR-112: Quantitative Biology [Semester I]

1. Bailey N. T. J. (1981). Statistical Methods in Biology. United Kingdom: Hodder and Stoughton. ISBN:9780340247563,
2. Brown D. and Rothery P. (1993). Models in biology: mathematics, statistics, and computing. United Kingdom: Wiley. ISBN: 9780471933229. Digitized 20th June 2009
3. Chetwynd A., Chetwynd A. G. and Diggle P. J. (2011). Statistics and Scientific Method: An Introduction for Students and Researchers. Italy: OUP Oxford. ISBN:9780199543182
4. Daniel W. W. and Cross C. L. (2018). Biostatistics: A Foundation for Analysis in the Health Sciences. United Kingdom: Wiley. ISBN:9781119282372
5. Doran P. M. (2013). Bioprocess Engineering Principles. Netherlands: Elsevier Science. ISBN:9780122208515
6. Gupta S. P. (2021). Statistical Methods. 46th edition. Sultan Chand & Sons Publisher, New Delhi. ISBN13:9789351611769
7. Haefner J. W. (2012). Modeling Biological Systems: Principles and Applications. United States: Springer US. ISBN:9781461541196
8. Harvey L. and McNeil B. (2008). Practical Fermentation Technology. Germany: Wiley. ISBN:9780470014349
9. Khan I. A. and Khanum A. (2016). Fundamentals of Biostatistics. 5th Edition. Ukaaz, Publications, Hyderabad. ISBN-13:9788190044103
10. Lindgren B. (2017). Statistical Theory. United Kingdom: CRC Press. ISBN: 9781351414173
11. Montgomery D. C. (2013). Design and Analysis of Experiments. Italy: Wiley. ISBN: 9781118097939
12. Newman S. C. (2003). Biostatistical Methods in Epidemiology. Germany: Wiley. ISBN:9780471461609
13. Petrie A. and Sabin C. (2019). Medical Statistics at a Glance. United Kingdom: Wiley. ISBN:9781119167815
14. Rosner B. (2016). Fundamentals of Biostatistics. United States: Cengage Learning. ISBN:9781305268920

	Semester I	
Credit	**PSMR-113 : Biochemistry and Metabolism** Core Compulsory Theory Paper Total:4 Credits Workload: -15 hrs /credit (Total Workload: - 4 credits x 15 hrs = 60 hrs in semester) Course outcome: 1. To understand the biochemical basis of life forms 2. To gain the energy transductions in biological processes 3. To understand the synthesis of biomolecules	**Lectures**
Credit I	**Protein Chemistry:** 1. Structural features of amino acids, classification of amino acids, Amino acids as buffers, 2. Henderson Hasselbalch equation and its role in buffer formulation Peptide linkage, partial double bond nature of peptide bond 3. Determination of primary structure of polypeptide (N-terminal, C-terminal determination, method of sequencing of peptides), 4. Structural classification of proteins: primary, secondary, tertiary, quaternary structures of proteins. 5. Non-covalent interactions, Conformational properties of proteins, Polypeptide chain geometry, Resonance forms of the peptide group, cis/trans isomers of peptide group Ramachandran plot (Molecular visualization tools, Uniprot). 6. Secondary, Super-secondary, Motif &Domain. 7. Tertiary and Quaternary structures of proteins, (Myoglobin & hemoglobin).	**15**
Credit II	**Biochemistry and Molecular Biology Techniques :** 1. Chromatography: Principles and applications of gel filtration, Ion exchange, affinity chromatography 2. Electrophoresis: Agarose, Native PAGE, SDSPAGE 3. Polymerase chain reaction: Principle, variations of PCR (Hot start, Nested, Reverse transcription, real time PCR) and its applications. 4. Sequencing methods: a) DNA and RNA sequencing: Classical and next generation sequencing methods (Pyro-sequencing, Ion torrent, Nano- pore sequencing) b) Concept of Local alignment and global alignment of DNA	**15**

	sequence	
Credit III	**Developmental Biology :** 1. Introduction to developmental biology. Different model systems used to study developmental biology 2. Conserved nature of development, Concepts of commitment, determination and differentiation. 3. Morphogen gradients in developmental regulation, Hox code, MPF 4. Gastrulation and cellular movements involved in it, Organizer and its importance giving examples of invertebrates (Drosophilla) and vertebrate (Xenopus) model systems, pattern formation in body axis, antero-posterior and dorso-ventral polarity. 5. Evolutionary Developmental Biology	**15**
Credit IV	**Cell biology :** 1. Structural organization and function of Endoplasmic Reticulum, Golgi apparatus, Nucleus, Mitochondrion, chloroplast, Lysosomes, peroxisomes; Cytoskeleton and function of Molecular motors. 2. Protein trafficking among various cellular compartments (by secretory and cytosolic pathway: targeting to secretory vesicles, cell membrane, lysosomes, nucleus, mitochondria and peroxisomes) 3. Events in cell cycle, Regulation of cell cycle. Apoptosis	15

Suggested References for PSMR-113 Biochemistry and Metabolism [Semester I]

Credit I and II : Protein Chemistry, Biochemistry and Molecular Biology Techniques

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

ISBN:9780470570951

Credit III : Development and Differentiation

1. Gilbert S. F. and Barresi M. J. F. (2020). Developmental Biology. United States: Oxford University Press.ISBN:9781605358222,
2. Müller W. A. (2012). Developmental Biology. United States: Springer New York. ISBN:9781461222484.
3. Wolpert L., Tickle C. and Martinez Arias A. (2015). Principles of Development. United Kingdom: Oxford University Press. ISBN:9780199678143
4. Hall B.K. (2012). Evolutionary Developmental Biology (Evo-Devo): Past, Present, and Future. *Evo Edu Outreach***5,** 184–193 https://doi.org/10.1007/s12052-012-0418-x

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

Semester I

PSMRP-114:Biochemical Techniques (Practical based on compulsory theory credits)

Core Compulsory Practical Paper

Total: 4Credits Workload: -30 hrs /credit

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

Course outcome:

1. To understand the methods of cell functioning
2. To gain approach for biological data analysis
3. To learn estimation methods for biomolecules

1. Safety 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)
4. Statistical analysis of data – Students t test, F test using computer software (Using Microsoft Excel)
5. Swiss PDB Viewer
6. 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. 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)
7. Studying the stages mitosis in growing tip of onion root cells and to observe polyploidy induced by colchicine treatment on root tip.
8. Demonstration of mounting of embryos (fruit fly) at various developmental stages on permanent slides
9. Extraction of Protein and Exo-polysaccharide from bacterial culture (may use TCA and ethanol method)
10. Colorimetry and spectrophotometry: estimation of above sample: Bradford and UV Spectrophotometry (purity using A_{280}method).
11. Chromatography: Separation of hydrolyzed protein and EPS sample (above) using

paper and thin layer chromatography. (*Explain concept of two-dimensional chromatography and descending chromatography*)

12. Electrophoresis: SDS-PAGE of above proteins / To determine the ion-exchange capacity and nature of given resin using anion exchange chromatography
13. 16S rRNA gene sequence analysis of bacteria by BLAST analysis and drawing phylogenetic tree using softwares

Suggested references PSMRP-114: Biochemical Techniques (Practical based on compulsory theory credits) [Semester I]

1. Safety 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
   - Fuscaldo A. (2012). Laboratory Safety Theory and Practice. United Kingdom: Elsevier Science.
   - Leboffe M. J. and Pierce B. E. (2010). Microbiology Laboratory theory and Application. Chapter 1. Introduction: Safety and laboratory guidelines. 3rd edition. Morton Publishing Company.1-8.
   - Plummer M. and Plummer D.T. (2001). Introduction to practical biochemistry. 3rd Edition, Tata McGraw- Hill Edition.
   - United States Environmental protection agency (EPA), EPA QA/G-6. 2007. Guidance for preparing SOP.1-6.
   - World Health Organization Staff, World Health Organization. Laboratory Biosafety Manual, 3/Ed. (2006). India: AITBS Publishers.
   - https://www.labmanager.com/lab-health-and-safety/science-laboratory-safety-rules-guidelines-5727
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.
   - Jayaraman J. (2004). Laboratory Manual in Biochemistry. India: New Age International (P) Limited Publishers.
   - Plummer M. and Plummer D.T. (2001). Introduction to practical biochemistry. 3rd Edition, Tata McGraw- Hill Edition.
   - Sadasivam S. and Manickam A. (2008). Biochemical methods. 3rd Edition, New Age International Publishers, India.
   - Segel I. H. (2010). Biochemical Calculations, 2nd Edn. India: Wiley India Pvt.Ltd.
3. Chromatography: Separation of hydrolysed protein and EPS sample (above) using paper and thin layer chromatography. (*Explain concept of two-dimensional chromatography and descending chromatography*)
   - 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
   - Jayaraman J. (2004). Laboratory Manual in Biochemistry. India: New Age International (P) Limited

Publishers.

- Plummer M. and Plummer D.T. (2001). Introduction to practical biochemistry. 3rd Edition, Tata McGraw- Hill Edition.
- Sadasivam S. and Manickam A. (2008). Biochemical methods. 3rd Edition, New Age International Publishers, India.

4. Electrophoresis: SDS-PAGE of above proteins / To determine the ion-exchange capacity and nature of given resin using anion exchange chromatography

- Plummer M. and Plummer D.T. (2001). Introduction to practical biochemistry. 3rd Edition, Tata McGraw- Hill Edition.
- Sadasivam S. and Manickam A. (2008). Biochemical methods. 3rd Edition, New Age International Publishers, India.

5. Interpretation of Ramachandran Plot and study of conformations of protein molecule using Molecular Graphics Visualization Tool (e.g., Swiss PDB)

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

	Semester I	
Credits	**PSMRELE-115A: Fungal Systematics and Bacterial Extremophiles** **Choice based Optional Theory Paper (Elective)** Total: 2Credits Workload: -15 hrs/credit (Total Workload: - 2 credits x 15 hrs = 30 hrs in semester) Course outcome: 1. To understand the classification in Fungi 2. To gain knowledge of biology of extreme environment 3. To learn the mechanisms of bacterial adaptation modes at harsh environmental conditions	**Lectures**
Credit I	**Fungal Systematics:** 1. Classification of Fungi 2. Differentiating characters among different Classes of fungi 3. Importance of morphological characters in fungal differentiation and classification	**15**
Credit II	**Extremophiles** 1. Enrichment, isolation, properties and application of extremophiles: Thermophiles, Psychrophiles, Halophiles, Acidophiles, Methanogens, alkalophiles 2. Concept of oligophiles 3. Adaptation mechanisms of extremophiles	**15**

Suggested References for PSMRELE-115A: Fungal Systematics and Bacterial Extremophiles [Semester I]

Credit I : Fungal Systematics:

1. Athearn Bessey E. (2020). Morphology and Taxonomy of Fungi. India: Alpha Editions. ISBN:9789354009730,
2. Barnett H. L. and Hunter, B. B. 1960. Illustrated Genera of Imperfect Fungi. Burgess Publishing Co., Minnesota.
3. Carlile M. J., Watkinson S. C. and Gooday G. W. (2001). The Fungi. Netherlands: Elsevier Science. ISBN:9780127384467
4. Lodder J. (1974). The Yeasts: A Taxonomic Study, North Holland Publishing Co. Amsterdam
5. Manoharachary C. and Mukerji K. G. (2010). Taxonomy and Ecology of Indian Fungi. India: I.K. International Publishing House Pvt. Limited. ISBN:9789380026923

Credit II : Extremophiles

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. Sharma V. and Salwan R. (2020). Physiological and Biotechnological Aspects of Extremophiles. Netherlands: Elsevier Science. ISBN:9780128183236
4. Stan-Lotter H., Oren A. and Seckbach J. (2013). Polyextremophiles: Life Under Multiple Forms of Stress. Netherlands: Springer Netherlands.
5. Subba Rao D. V. and Durvasula R. V. (2018). Extremophiles: From Biology to Biotechnology. United States: CRC Press. ISBN: 9781351650731

	Semester I	
Credits	**PSMRELEP-115A: Practicals Based on Fungal Systematics and Bacterial Extremophiles** **Choice based Optional Practical Paper (Elective)** Total: 2Credits Workload: -30 hrs/credit (Total Workload: - 2credits x 30 hrs = 60 hrs in semester) Course outcome: 1. To understand the methods of Fungal classification 2. To get acquaintance with life forms at extreme environments 3. To understand the mechanisms of bacterial adaptation modes at harsh environmental conditions	**Lectures**
Credit I	**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)*	**30**
Credit II	**Isolation and identification of the following extremophiles from natural samples: Acidophiles / Halophiles /oligophiles (any two)** 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)*	**30**

Suggested References for PSMRELEP-115APracticals Based on Fungal Systematics and Bacterial Extremophiles [Semester I]

Credit I : Isolation and identification of yeasts and saprophytic molds from natural samples.

- Alexopoulos C. J., Mims C. W. and Blackwell M. (2007). Introductory Mycology, 4th Edition. India: Wiley India Pvt. Limited.
- Bills G. F., Mueller G. M. and Foster M. S. (2011). Biodiversity of Fungi: Inventory and Monitoring

Methods. Netherlands: Elsevier Science.

- Deacon J. W. (2013). Fungal Biology. Germany: Wiley.
- Hudson H. J. (1992). Fungal Biology. United Kingdom: Cambridge University Press.
- Kreger-Van Rij N. J. W. (2013). The Yeasts: A Taxonomic Study. Netherlands: Elsevier Science.

Credit II : Isolation and identification of the following extremophiles from natural samples:

Acidophiles : -

- 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 Biosci Bioeng. 104(2):117-123. doi: 10.1263/jbb.104.117.
- 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
- 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 : -

- 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.
- 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.
- 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.

	Semester I	
Credit	**PSMRELE-116B: Experimental Design and Quantitative approaches for Biologists** **Choice based Optional Theory Paper (Elective)** Total: 2 Credits Workload: -15 hrs /credit (Total Workload: - 2credits x15 hrs = 30 hrs in semester) Course outcome: 1. To learn about biological process optimization 2. To know factorial variables in biological systems 3. To get concepts on mathematical modellings in biology	**Lectures**
Credit I	**Experimental Design:** 1. Research Methodology 2. Sampling methods, sampling errors 3. Survey design, DOE in Agriculture (randomization, replication and local control), designs- CRD, RCBD and LSD 4. Factorial design (Full, Fractional, Plackett Burman and Response Surface Methodology) 5. Epidemiological Study designs: Case control, cohort, concurrent, cross-sectional, retrospective/prospective 6. Clinical/field trials-Randomization, Bias removal (Blinding – single and double), controlled and uncontrolled trials	**15**
Credit II	**Mathematical approach for Biologists** *(Basic rules and application of limits, derivative and integration need to be discussed)* 7. Presentation of experimental data (Tables, graphs and equations) 8. Data Analysis (Trends, Testing mathematical models, Goodness of fit: Least Square Analysis, Linear and Non-linear models) 9. Concept of mathematical model, need, modeling the system of interest, modeling the data Deterministic Vs Stochastic model, Cyclic processes of model construction, verification and applications	**15**

Suggested references for PSMRELE-116B: Experimental Design and Quantitative approaches for Biologists

1. Bailey N. T. J. (1995). Statistical Methods in Biology. United Kingdom: Cambridge University Press.
2. Gupta S. P. (2021). Statistical Methods. 46th edition. Sultan Chand & Sons Publisher, New Delhi.

ISBN13:9789351611769

3. Haaland P. D. (2020). Experimental Design in Biotechnology. United States: CRC Press.
4. Jaberi-Douraki M. and Moghadas S. M. (2018). Mathematical Modelling: A Graduate Textbook. Germany: Wiley.
5. Khan I. A. and Khanum A. (2016). Fundamentals of Biostatistics. 5th Edition. Ukaaz, Publications, Hyderabad. ISBN-13:9788190044103
6. Locker A. and Krüger F. (2014). Quantitative Biology of Metabolism: Models of Metabolism, Metabolic Parameters, Damage to Metabolism, Metabolic Control. United States: Springer Berlin Heidelberg.
7. Montgomery D. C. (2013). Design and Analysis of Experiments. Italy: Wiley. ISBN: 9781118097939
8. Müller J. and Kuttler C. (2015). Methods and Models in Mathematical Biology: Deterministic and Stochastic Approaches. Germany: Springer Berlin Heidelberg.
9. Newman S. C. (2003). Biostatistical Methods in Epidemiology. Germany: Wiley.
10. Petrie A. and Sabin C. (2019). Medical Statistics at a Glance. United Kingdom: Wiley.
11. Reid N., Reid N. and Cox D. (2000). The Theory of the Design of Experiments. United States: CRC Press.
12. Rosner B. (2016). Fundamentals of Biostatistics. United States: Cengage Learning.
13. Voss D., Draguljić D. and Dean A. (2017). Design and Analysis of Experiments. Germany: Springer International Publishing.

	Semester I	
Credit	**PSMRELEP-116B: Practicals based on Experimental Design and Quantitative approaches for Biologist** **Choice based Optional Practical Paper (Elective)** Total: 2Credits Workload: -30 hrs /credit (Total Workload: - 2 credits x30 hrs = 60 hrs in semester) Course outcome: 4. To learn about methods of process optimization in bacteria 5. To analyze factorial variables in biological systems 6. To learn mathematical modellings for biological systems	**Lectures**
Credit I	**Practicals based on theory credit Designing of experiments** 1. Designing of Mock Research Proposal which includes: a) Title b) Hypothesis c) Review of Literature *d)* Methodology *(Specify Statistical Methods)* *e)* Possible outcomes *(Statistical Interpretations)* f) References *Scientific writing should be followed for Research proposal* 2. Epidemiological study Proposal *(Mini Project)* a) Identification of Problem and Establishing Hypothesis b) Selection of Design c) Data Collection d) Data Analysis e) Data Presentation f) Conclusion 3. *Scientific writing should be followed for proposal* Statistical Survey a) Identification of Problem and Establishing Hypothesis b) Survey Design (Questionnaire based)	**30**

	c) Preparation of Questionnaire d) Data Collection e) Data Analysis f) Data Presentation g) Conclusion of Survey *(Actual statistical survey need to be carried out to demonstrate its mechanism*). 4. Factorial Study Design (Placket barmen, Fractional Factorial and full factorial) for Optimization of Media conditions a) Data collection from Research Papers/ Dissertations/Journals Data Treatment using Statistical Software's (Mini tab, SPSS and Design Expert)	
Credit II	**Practicals based on theory credit Mathematical approach for Biologists** 1. Numerical Microbiology Problem solving: Unit conversion, Numerical Problems on size, volume, number (CFU and PFU), dilutions, Neubauer chamber, direct microscopic count, Numerical Problems on Bacterial Growth. Numerical problems on diversity indices 2. Computer applications: Using data sheets, and sorting data with different parameters, plotting graphs – bar charts, line graphs, pie charts, adding error bars. (*Using Statistical Packages other than Microsoft Excel)* 3. Statistical analysis of data – Students t test, ANOVA, Chi square test, F test using computer software (*Using Statistical Packages other* *than Microsoft Excel*)	**30**

Suggested References: PSMRELEP-116B: Practicals based on Experimental Design and Quantitative approaches for Biologist

Credit I : Practicals based on theory credit Designing of experiments

1. Designing of Mock Research Proposal which includes:

- Gastel B. and Day R. A. (2016). How to Write and Publish a Scientific Paper. United States: ABC-CLIO, LLC.
- Kothari C. R. (2004). Research methodology methods and techniques. 2nd revised edition. New age international publisher.

2. Epidemiological study Proposal *(MiniProject)*

- Brown D. and Rothery P. (1993). Models in biology: mathematics, statistics, and computing. United Kingdom: Wiley. ISBN: 9780471933229. Digitized 20th June 2009

  NewmanS.C.(2003).Biostatistical Methods in Epidemiology.
  Germany:Wiley. ISBN:9780471461609

3. Statistical Survey

- Acharya R. and Roy T. K. (2016). Statistical Survey Design and Evaluating Impact. India: Cambridge University Press.
- Nardi P. M. (2018). Doing Survey Research: A Guide to Quantitative Methods. United Kingdom: Taylor & Francis.
- Singh Y. K. (2006). Fundamental of Research Methodology and Statistics. India: New Age International (P) Limited.

4. Factorial Study Design (Placket barmen, Fractional Factorial and full factorial) for Optimization of Media conditions

- Harvey L. and McNeil B. (2008). Practical Fermentation Technology. Germany: Wiley.
- Montgomery D.C. (2013). Design and Analysis of Experiments. Italy : Wiley. ISBN: 9781118097939

Credit II: Practicals based on Theory Mathematical approach for Biologists

3. Numerical Microbiology Problem solving: Unit conversion, 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

- Aneja K. R. (2007). Experiments In Microbiology, Plant Pathology and Biotechnology. India: New Age International.
- Cappuccino J. G. and Welsh C. T. (2017). Microbiology: A Laboratory Manual. eBook, Global Edition. United Kingdom: Pearson Education.

- Green L. H. and Goldman E. (2008). Practical Handbook of Microbiology. United States: CRCPress.
- Pommerville J. C. (2010). Alcamo's Laboratory Fundamentals of Microbiology. United States: Jones & Bartlett Learning, LLC.
- Tate R. L. (1986). Microbial Autecology: A Method for Environmental Studies. Digitized 2009. United Kingdom:Wiley.

4. Computer applications: Using data sheets, and sorting data with different parameters, plotting graphs – bar charts, line graphs, pie charts, adding error bars. (*Using Statistical Packages other than Microsoft Excel*)

- Boslaugh S. (2012).Statistics in a Nutshell. Germany : O'Reilly Media Incorporated ISBN: 9781449316822
- Conner N. and MacDonald M. (2013). Office 2013: The Missing Manual. United States: O'Reilly Media.
- McFedries P. (2019). Microsoft Excel 2019 Formulas and Functions. Pearson Education.
- https://www.britannica.com/technology/spreadsheet

3. Statistical analysis of data – Students t test, ANOVA, Chi square test, F test using computer software (*Using Statistical Packages other than Microsoft Excel*)

- Boslaugh S. (2012). Statistics in a Nutshell. Germany: O'Reilly Media Incorporated. ISBN:9781449316822
- Khan I. A. and Khanum A. (2016). Fundamentals of Biostatistics. 5th Edition. Ukaaz, Publications, Hyderabad. ISBN-13:9788190044103
- McFedries P. (2019). Microsoft Excel 2019 Formulas and Functions. Pearson Education
- Salkind N. J. (2016). Statistics for People Who (ThinkThey) Hate Statistics : Using Microsoft Excel 2016. United States: SAGE Publications.

	Semester I	
Credit	**PSMRELE-117C: Microbial communication, Membrane transport and signal transduction** **Choice based Optional Theory Paper (Elective)** Total: 2 Credits Workload: -15 hrs /credit (Total Workload: - 2 credits x 15 hrs = 30 hrs in semester) Course outcome: 1. To learn about cell to cell communications 2. To know transport of substances across cell 3. To know importance of signaling in bacteria	**Lectures**
Credit I	**Communication and Coordination among microorganisms** 1. Life cycle of *Dictyostelium discoideum*, Molecular mechanism of quorum sensing in slime molds, 2. Life cycle of myxobacteria, Molecular mechanism of quorum sensing in myxobacteria. 3. Quorum sensing in Gram positive and Gram-negative bacteria, 4. Concept of quorum quenching 5. Biofilms, their organization, signals involved in their formation and dispersal 6. Applications of study on biofilms in pathogenic and non-pathogenic environments	**15**

Credit II	**Membrane transport and signal transduction** 6. The composition and architecture of membranes, Membrane dynamics, 7. Solute transport across membranes: Passive diffusion, facilitated transport, primary and secondary active transport using P, V and F type ATPases 8. Ionophores, Ion mediated transport, transport of ions across membranes (ion pumps), ligand and voltage gated ion channels 9. Liposomes and model membrane 10. Signal transduction pathways in bacteria, second messengers, regulation of signaling pathways, bacterial two-component systems, chemotaxis.	**15**

Suggested References for PSMRELE-117C: Microbial communication, Membrane transport and signal transduction [Semester 1]

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 BaselAG.

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 Signalling 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.

Semester I

PSMRELEP-117C: Practicals Based on Microbial communication, Membrane transport and signal transduction

Choice based Optional Practical Paper (Elective)

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

Course outcome:

4. To learn about cell to cell communications mechanisms
5. To know transport of substances across cell and their effects
6. To know importance of signaling in bacteria and their application

Practicals Based on Credit I: Communication And Coordination among microorganisms

1. Crystal violet assay for estimation of biofilm formation
2. Bioassay for determination of quorum sensing signals produced by bacteria.
3. Determination of chemo-taxis responses shown by bacteria using agar plate or capillary tube method.

Practicals Based on Credit II : Membrane transport and signal transduction

4. Study principles of osmosis and diffusion using artificial membranes (dialysis membrane) (explain how various physical and chemical factors affect the diffusion)
5. Different methods of cell disruption.
6. Swab evaluation with respect to transport of bacterial sample..

Suggested References for PSMRELEP-117C: Practicals Based on Microbial communication, Membrane transport and signal transduction

1. Crystal violet assay for estimation of biofilm formation:

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

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

- Martín-Rodríguez A. J. and Fernández J. J. (2016). A bioassay protocol for quorum sensing studies using *Vibrio campbellii*. Bio Protoc. 6:e1866
- Papenfort K. and Bassler B. (2016). Quorum sensing signal-response systems in Gram-negative bacteria. Nat. Rev. Microbiol. 14:576–588.10.1038/nrmicro.2016.89.

Determination of chemo-taxis responses shown by bacteria using agarplate or capillary tube method:

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

Practical based on Credit II : Membrane transport and signal transduction

4. Study principles of osmosis and diffusion using artificial membranes (dialysis membrane) (explain how various physical and chemical factors affect the diffusion):
   - Ravindra Babu B., Rastogi N.K. and Raghavarao K.S.M.S. (2006). Effect of process parameters on transmembrane flux during direct osmosis. Journal of Membrane Science. 280(1–2):185-194
   - Stillwell W. (2016). Membrane Transport. An Introduction to Biological Membranes. 23–451. doi: 10.1016/B978-0-444-63772-7.00019-1. PMCID: PMC7182109
5. Different methods of cell disruption:
   - https://microbenotes.com/cell-disruption-methods/
   - Islam M. S., Aryasomayajula A. and Selvaganapathy P. R. (2017). A Review on Macroscale and Microscale Cell Lysis Methods. Micromachines (Basel). 8(3): 83. doi: 10.3390/mi8030083 Swab evaluation with respect to transport of bacterialsample:
   - HumanR.P.andJonesG.A.(2004). Evaluation of swab transport systems against a published standard. J Clin Pathol. 57:762–763. doi: 10.1136/jcp.2004.016725.

	Semester II	
Credit	**PSMR-121: Instrumentation and Molecular Biophysics** **Core Compulsory Theory Paper** **Total: 4 Credits Workload: -15 hrs /credit** **(Total Workload: - 4 credits x 15 hrs = 60 hrs in semester)** Course outcome: 1. To get concepts of biophysics 2. To learn physicochemical techniques of understanding biomolecules structure and functions 3. To learn magnification systems for microbes	**Lectures**
Credit I	**Separation and analysis of biomolecules:** 1. Techniques for sample preparation: Dialysis, ultra-filtration, centrifugal vacuum concentration 2. Chromatography- i. Partition Coefficient, Selectivity, Resolution, Column Efficiency, Van Deemter equation, Interpretation of chromatograms, ii. Principle, instrumentation and applications of High Performance Liquid Chromatography (HPLC), iii. Supercritical Fluid Chromatography iv. Reversed Phase Chromatography and Gas chromatography. 3. Electrophoresis Methods: Pulse field gel electrophoresis, capillary electrophoresis, isoelectric focusing, 2-dimensional electrophoresis, immune-Electrophoresis 4. Numerical Problems based on chromatography	**15**

Credit II	**Spectroscopy** 4. Introduction: Electromagnetic spectrum, Atomic orbitals, Molecular orbitals, Electronic, Rotational and Vibrational transitions in spectroscopy, Interpretation of spectra. 5. UV/Visible spectroscopy- Instrumentation, Molar Absorptivity, Beer and Lamberts Law, Bathochromic and hypochromic shifts. 6. Fluorescence spectroscopy- Instrumentation, Quantum Yield, Quenching, FRET, Binding and Folding studies, 7. Flow cytometry and FACS 8. Infrared spectroscopy- Principle, Instrumentation, Absorption bands, FTIR and its applications 9. Mass spectroscopy- Principles of operation, Ionization, Ion fragmentation, Mass Analysers, GC- MS, MALDI-TOF 10. Numerical Problems	15
Credit III	**Biophysical Techniques** 1. NMR spectroscopy: i. Basic Principles of NMR, Chemical shift, Intensity, Line width, Relaxation parameters, Spin coupling, ii. Nuclear Over hauser Effect Spectroscopy, Correlation Spectroscopy, Approach to structure determination by 2D- NMR 2. X-ray crystallography: i. Purification of proteins, Crystallization of proteins, Instrumentation, ii. acquisition of the diffraction pattern, basic principles of x-ray diffraction, iii. Crystal Structures (Bravais Lattices), Crystal planes and Miller Indices, Direct Lattice and Reciprocal lattice, iv. Fourier Transform and Inverse Fourier, v. Ewald sphere, Electron density Maps, Phase determination	15

Credit IV	**Radioisotopes in Biology and Confocal Microscopy** 1. Radioisotopes in Biology: i. Principles and applications of radio tracers in medicine, agriculture, industry, and fundamental research ii. Radiation and Radioactive isotopes: Types, Quantities and units of estimation, half-life of isotopes iii. Detection and measurement of radioactivity- Autoradiography, Liquid scintillation counting. iv. Effect of radiation on biological system v. Numerical Problems **2.Confocal Microscopy:** i. Scanning optical microscope, confocal principle, ii. Resolution and point spread function, light source: gas lasers & solid-state, primary beam splitter; beam scanning, iii. Pinhole and signal channel configurations, detectors; pixels and voxels; contrast, iv. Spatial sampling: temporal sampling: signal-to noise ratio, multichannel images v. Applications in bacteriology	15

Suggested References: PSMR-121: 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 Private. Limited.
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.

	Semester II	
Credit	**PSMR-122: Molecular Biology** Core Compulsory Theory Paper Total: 4 Credits Workload: -15 hrs /credit (Total Workload: - 4 credits x 15 hrs = 60 hrs in semester) Course outcome: 1. To learn tools in genetic engineering 2. To gain information about genome projects 3. To learn applications of molecular techniques	**Lectures**
Credit I	**RNA processing &Molecular Techniques** **1. Eukaryotic RNA Processing:** i. mRNA splicing, rRNA processing; tRNA processing and RNA Editing, ii. Nuclear export of mRNA iii. Regulatory RNAs and functions of noncoding RNAs: Si RNA, Micro RNA, RNA interference (RNAi) iv. Pi RNA (Piwi interacting RNAs) **2. Molecular Techniques:** Knockout mice, phage display system, yeast two and three hybrid assay, Activity gel assay, DNA helicase assay, Chromatin Immuno-precipitation (ChIP), Designing probe and Epitope tagging.	**15**

Credit II	**Tools for Genetic engineering** 3. i. Enzymes: Restriction endonucleases and methylases, DNA ligase, T4 RNA ligase, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase. ii. Cohesive and blunt end ligation, linkers, adaptors, homopolymeric tailing labeling of DNA iii. Nick translation, radioactive, non- radioactive probes, RFLP (restriction fragment length polymorphism) and end filling technique 4. Hybridization techniques: Northern, Southern and south-western 5. Vectors for cloning and gene expression: i. Plasmids; Bacteriophages; YACS (yeast artificial chromosomes), PUC19 and Bluescript vectors, *Baculovirus* and *Pichia* vectors, plant-based vectors (Ti and Ri as vectors). ii. Protein tagging and purification (His-tag, GST-tag, MBP-tag) 6. Construction of genomic DNA and cDNA libraries	**15**
Credit III	**Genome projects** 6. i. Concept of genome projects ii Applications of genome projects 7. Introduction to Genome projects of *E. coli*, yeast (*Saccharomyces cerevisia*), Plasmodium, Mouse (Mus musculus), Drosophila, Rice (Oryza sativa) and comparative genomics 8. Gene annotation 9. Human Genome project and its applications	15

Credit IV	**Molecular diagnostics and applications** 11. Introduction to protein array, protein arrays to detect polygenic diseases, Immunoassay for protein confirmation in specific disorders 12. Detection of diseases-associated changes in gene expression using microarray 13. Detection of RNA signatures of' Antibiotic Resistance in bacteria 14. Detection of micro RNA (miRNA): A signature of cancer diagnostics	15

Suggested References for PSMR-122 : Molecular Biology [Semester II]

1. Goldstein E. S., Krebs J. E. and Kilpatrick S. T. (2017). Lewin's GENES XIAlberts B. (2017). Molecular Biology of the Cell. Sixth Edition. United States: W.W. Norton.
2. Amon A., Berk A., Martin K. C., Lodish H., Kaiser, C. A., Ploegh H., Krieger M., Bretscher A. (2016). Molecular Cell Biology. United States: Macmillan Learning.
3. Cooper G. M. and Hausman R. E. (2007). The Cell: A Molecular Approach. United Kingdom: ASMPress.
4. Farrell Jr. R. E. (2017). RNA Methodologies: Laboratory Guide for Isolation and Characterization. United Kingdom: Elsevier Science.
5. Garg N. and Kumar A. (2005). Genetic engineering. New York: Nova Biomedical Books. Applications of Recombinant DNA. United Kingdom: Wiley.
6. Goldstein E. S., Kilpatrick S. T. and Krebs J. E. (2017). Lewin's GENES XII. United States: Jones & Bartlett Learning.
7. GlickB.R.andPattenC.L.(2017).Molecular Biotechnology: Principles and I. United States: Jones & Bartlett Learning.
8. Goot J. M. and. Emeson R. B. (2000). Functions and Mechanics of RNA editing. Annual Review of Genetics. 34:499-531. https://doi.org/10.1146/annurev.genet.34.1.499
9. Hwang H. W. and Mendell J. T. (2006). MicroRNAs in cell proliferation, cell death and tumorigenesis. Br J Cancer. 94(6): 776-80. doi:10.1038/sj.bjc.6603023.

10. Karp G. (2010). Cell and Molecular Biology: Concepts and Experiments. United Kingdom: Wiley.
11. 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.
12. Kloc M., Zearfoss N. R., Etkin L. D. (2002). Mechanisms of subcellular mRNA localization. Cell. 108(4): 533-544. doi:10.1016/s0092-8674(02)00651-7.
13. Klug W. S., Cummings M. R. Spencer C. A., Killian D. and Palladino M. A. (2019). Concepts of Genetics. United States: Pearson.
14. Levine M., Baker T. A., Losick R., Bell S. P., Watson J. D. and Gann A. (2014). Molecular Biology of the Gene. United Kingdom: Pearson.
15. Lodish H., Berk A., Kaiser C. A., Krieger M., Bretscher, A. Ploegh H., Amon A. and Martin K. C., (2016). Molecular Cell Biology. United Kingdom: W. H.Freeman.
16. Nakanishi K. and Nureki O. (2005). Recent progress of structural biology of tRNA processing and modification. Mol Cells. 19(2):157-66
17. Reece R. J. (2004). Analysis of Genes and Genomes. United Kingdom: John Wiley & Sons.
18. Taft R. J., Pang K. C., Mercer T. R., Dinger M. and Mattick J. S. (2010). Non-coding RNAs: regulators of disease. J Pathol. 220(2): 126-139. doi:10.1002/path.2638.
19. Twyman R. and Primrose S. B. (2009). Principles of Genome Analysis and Genomics. Germany:Wiley.
20. Voet J. G. and Voet D. (2011). Biochemistry. United Kingdom:Wiley.
21. 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
22. Weaver R. F. (2008). Molecular Biology. Singapore: McGraw-Hill.

	Semester II	
Credit	**PSMR-123Enzymology, Bioenergetics and Metabolism** Core Compulsory Theory Paper Total: 4Credits Workload: -15 hrs /credit (Total Workload: - 4 credits x 15 hrs = 60 hrs in semester) Course outcome: 1. To learn about synthesis and break down mechanism in bacteria 2. To learn about biological catalysts 3. To learn energy transformations in bacteria	**Lectures**
Credit I	**Enzymology:** 1. Overview of 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. 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. 4. Problems based on 1and 2	**15**

Credit II	**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. Principle of Differential Scanning Calorimetry. 6. Problems based on 2 and4. 7. Atkinson's energy charge.	**15**
Credit III	**Lipid Chemistry and Metabolism:** 1. Classification of lipids according to chemical structure, 3. Fatty acids, saturated, unsaturated, branched, nomenclature system, 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 s acid) and fats in animals 7. Lipids as signal molecules (eg. phosphatidyl inositol, eicosanoids).	**15**
Credit IV	**Carbohydrate Chemistry and Metabolism:** 1. Classification of carbohydrates with examples 2. Isomerism in biologically significant sugars: asymmetric centers in sugars, dextro, leavo-rotatory, sugar anomers (reducing and non-reducing sugars), sugar epimers 3. Derivatives of sugars such as sugar alcohols, amino sugars, sugar acids, deoxy sugars 4. Overview of Glycolysis and gluconeogenesis, Regulation of glycolysis and gluconeogenesis,	**15**

	5. Synthesis of microbial exopolysaccharides(alginate) 6. Cellulose metabolism 7. Regulation of Glycogen synthesis; breakdown, 8. TCA cycle-regulation, role in energy generation, Role in generating biosynthetic intermediates and glyoxylate cycle	

Suggested References PSMR-123: Enzymology, Bioenergetics and Metabolism [Semester II]

1. Cornish-Bowden A. (2014). Fundamentals of Enzyme Kinetics. Netherlands: Elsevier Science.
2. Farrell S. O., Bettelheim F. A., Torres O., Brown W. H. and Campbell M. K. (2015). Introduction to General, Organic and Biochemistry. United States: Cengage Learning.
3. Ferguson S. J. and Nicholls D. G. (2014). Bioenergetics 2. United Kingdom: Elsevier Science.
4. Frayn K. N., Gurr M. I. and Harwood J. L. (2008). Lipid Biochemistry: An Introduction. Germany:Wiley.
5. Garrett R. H. and Grisham C. M. (2013). Biochemistry. 5th Edition. Brooks/Cole, Publishing Company, California. ISBN-13:978-1-133-10629-6
6. Hervé G., Yon-Kahn J. (2011). Molecular and Cellular Enzymology. Germany: Springer Berlin Heidelberg.
7. Kim B. H. and Gadd G. M. (2019). Prokaryotic Metabolism and Physiology. United Kingdom: Cambridge UniversityPress.
8. Leskovac V. (2007). Comprehensive Enzyme Kinetics. Netherlands: Springer US.
9. Madigan M. T., Sattley W. M., Bender, K. S., Stahl D. A., Buckley, D. H. (2018). Brock Biology of Microorganisms. United Kingdom:Pearson.
10. McQuillen K., Dawes I. W. and Mandelstam J. (1982; Digitized 2010). Biochemistry of bacterial growth. United Kingdom:Wiley.
11. Meena Kumari S. (2019). Microbial Physiology. United Kingdom: MJP Publisher.
12. Moat A. G. Foster J. W. and Spector M. P. (2003). (Microbial Physiology. Germany: Wiley.
13. Nelson D. L. and Cox M. M. (2021). Lehninger's Principles of Biochemistry.8th Edition. Mac Millan Worth Pub. Co. New Delhi. ISBN: 9781319228002
14. Palmer T. and Bonner P. L. (2007). Enzymes: Biochemistry, Biotechnology,

Clinical Chemistry. United Kingdom: Elsevier Science.

15. Punekar N. (2018). ENZYMES: Catalysis, Kinetics and Mechanisms. Germany: Springer Singapore.
16. Segel I. H. (2010). Biochemical Calculations. 2nd Ed. Wiley India Pvt. Ltd.
17. Shirley, Bret A. (1995). *Protein Stability and Folding || Differential Scanning Calorimetry. , 10.1385/0896033015(), 191–218.* doi:10.1385/0-89603-301-5:191
18. Tymoczko J. L., Berg J. M., Stryer L., Gatto G. J. (2015). Biochemistry. UnitedStates: W. H. Freeman.
19. Vance D. E. and Vance J. (Editors). Biochemistry of Lipids, Lipoproteins and Membranes. (2002). Netherlands: Elsevier Science.
20. White D., Fuqua C., Drummond J. and Drummond J. T. (2012). The physiology and biochemistry of prokaryotes. United Kingdom: Oxford University Press.

Semester II

PSMRP-124: Molecular biology, Enzymology and Instrumentation Techniques (Practical based on compulsory theory credits)

Total: 4 Credits Workload: -30 hr/credit

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

Course outcome:

1. To learn about modern techniques of DNA analysis
2. To know basis of scientific writing
3. To understand kinetic basis of biocatalysts

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1. Plasmid DNA isolation, DNA quantitation and characterization by gel electrophoresis.
2. Construction of restriction digestion map of plasmid DNA
3. Curing of bacterial Plasmid
4. Gene annotation (RAST)
5. Digital DNA- DNA hybridization and Genome to genome calculation.
6. Purification of enzymes (Amylase/Invertase): (ammonium sulphate precipitation, organic solvent precipitation, gel filtration (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. Isolation and characterization of lipase/cellulase/chitinase producing microbe. (ANY ONE)
11. Scientific writing :

Concept of effective communication: Presentation skills, formal scientific presentation skills; Preparing power point presentation, Presenting the work, Scientific poster preparation and 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). Mock research paper writing as an assignment. 12. Virtual lab exercise to understand the instrumentation, experimentation and interpretation of data obtained using HPLC, FTIR, GC-MS, MALDI TOF, SEM, TEM, AFM, Confocal Microscope (representative websites) 13. Visit to any lab or institute to understand the principle and working of the bio-analytical instrument studied in theory courses (optional)

Suggested References PSMRP-124: Molecular biology, Enzymology and Instrumentation Techniques (Practical based on compulsory theory credits) [Semester II]

1. Plasmid DNA isolation, DNA quantitation and characterization by gel electrophoresis:
   - 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
   - Sambrook J. and Russell D. (2001) Molecular Cloning: A Laboratory Manual, 3rd edition. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

2. Construction of restriction digestion map of plasmid DNA:
   - Russell P. J. (2010). iGenetics: A Molecular Approach. 3rd edition. Pearson Education, Inc., publishing as Pearson Benjamin Cummings, SanFrancisco
   - WatsonJ.D.,GannA.,BakerT.A.,LevineM.,BellS.P.,LosickR.andHarrison S. C. (2014). Molecular Biology of the genes. 7th edition. Cold Spring Harbor Laboratory Press. Cold Spring Harbor, New York

3. Curing of bacterial Plasmid: 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
   - Trevors J. T. (1986). Plasmid curing in bacteria**.** FEMS Microbiology Reviews 32:149-157

4. Gene annotation:

- Archer C.T., Kim J.F., Jeong H., Park J. H., Vickers C. E., Lee S. Y. and NielsenL. 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
- Webster D. M. (Editor). Protein Structure Prediction: Methods and Protocols. In: Methods in Molecular Biology; Volume 143. HumanaPress.

5. Digital DNA- DNA hybridization and Genome to genome calculation https://www.dsmz.de/services/online-tools/genome-to-genome-distance-calculator-ggdc
6. Purification of enzymes (Amylase/Invertase): Aammonium sulphate precipitation, organic solvent precipitation, gel filtration (any two methods); Establishment of enzyme purificationchart.

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

7. Determination of Km, Vmax and Kcat values ofenzyme:

- Miquet J. G., González L., Sotelo A. I. and González Lebrero R. M. (2019). A laboratory work to introduce biochemistry undergraduate students to basic enzymekinetics-alkalinephosphataseasamodel.BiochemMolBiolEduc. 47(1):93-99. doi: 10.1002/bmb.21195.
- Palmer T. and Bonner P. L. (2007). Enzymes: Biochemistry, Biotechnology, Clinical Chemistry. United Kingdom: Elsevier Science.

8. Determination of molecular extinction coefficient ofbiomolecule:

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

- Wilson K. and Walker J. (2005) Principles and Techniques of Biochemistry and Molecular Biolog. 6th edition. Cambridge University Press, NewYork. Aflatoxins:

9. Aflatoxins:

9. a) Isolation of Aflatoxin producing organism.

- 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
- 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

9.b) Extraction and detection of Aflatoxin infood:

- Braicu C., Puia C., Bodoki E. and Socaciu C. (2008). Screening and quantification of aflatoxins and ochratoxin a 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.x
- 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

10. Isolation and characterization of lipase/ cellulase / chitinase producingmicrobe: 10.i) Lipase:

- 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 mori*, reared on different forage. J Insect Sci.11: 135. doi: 10.1673/031.011.13501.
- IlesanmiO.I.,AdekunleA.E.,OmolaiyeJ.A,OlorodeE.M.andOgunkanmiA.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.

10.ii) Cellulase:

- 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.
- Sulyman A. O., Igunnu A. and Malomo S. O. (2020). Isolation, purification and

characterization of cellulase produced by *Aspergillus niger*cultured on *Arachis hypogaea* shells. Heliyon. 6: 12; e05668. https://doi.org/10.1016/j.heliyon.2020.e05668.

10.iii) Chitinase:

- 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
- Shahbaz U. and Yu X. (2020). Cloning, isolation, and characterization of novel chitinase-producing bacterial strain UM01 (*Myxococcus fulvus*). J Genet Eng Biotechnol. 18, 45.https://doi.org/10.1186/s43141-020-00059-1

11. Scientific Communication and Research Methodology:
(*Assignment/activity-based teaching method may beused*):

11.a) 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 datamining.

- Day R. A. and Gastel B. (2011) How to write an publish a scientific paper, seventh Edition. Greenwood,California
- Kotahri C. R. 2004. Research Methodology - Methods & Techniques. New age International (p) Limited, Publishers.New Delhi,India.
- Van Cleemput O. and Saso L. (2017). Manual on Scientific Communication for Postgraduate Students and Young Researchers in Technical, Natural, and Life Sciences. DOI: 10.5772/intechopen.69870. Availablefrom:
- https://www.intechopen.com/chapters/56191

	Semester II	
Credit	**PSMRELE-125A Bioinformatics and Bio-nanotechnology** **Choice based Optional Theory Paper (Elective)** **Total:2Credits Workload: -15 hrs /credit** **(Total Workload: - 2 credits x 15 hrs = 30 hrs insemester)** Course outcome: 1. To learn about genomic sequences and their data bases 2. To get concepts of nanoscience 3. To learn applications of magnification systems	**Lectures**
Credit I	**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. Submission of genetic data to the data banks (NCBI, PDB) 3. 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	**15**

Credit II	**Techniques in Bio-nanotechnology** 4. Biogenic nanoparticles – Synthesis and applications. Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Role of plants in nanoparticle synthesis. 5. Significance of the physical properties of nanoparticles 6. Characterization of nanoparticles Dynamic Light Scattering (DLS), EDAX analysis, Zeta analysis 7. Imaging techniques to characterize nanoparticles: Principle, instrumentation and applications of: i. TEM (Transmission Electron Microscope) ii. SEM (Scanning Electron Microscope) iii. Scanning Probe Microscopy (SPM) iv. AFM (Atomic Force Microscopy)	**15**

Suggested ReferencesPSMRELE-125A: Bioinformatics and Bio nanotechnology. [Semester II]

1. Bal H. P. (2003). Perl Programming for Bioinformatics. India: Tata McGraw-Hill. Ingvar
2. Baxevanis A. D., Ouellette B. F. F. (2009). Bioinformatics: a practical guide to the analysis of genes and proteins. 3rd Edition. India: Wiley India Pvt. Limited.
3. Eidhammer I., Taylor W. R., Jonassen I., Taylor W. R., Taylor W. R. (2004). Protein bioinformatics: an algorithmic approach to sequence and structure analysis. United Kingdom: Wiley.
4. Mallick B. and Ghosh Z. (2008). Bioinformatics: Principles and Applications. India: Oxford University Press.
5. Mount D. W. (2005). Bioinformatics: Sequence and Genome Analysis.India: CBS Publishers & Distributors.
6. Narayanan P. (2007). Essentials of Biophysics. India: New Age International.
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8. Ramsden J. J. (2012). Bioinformatics: An Introduction. Netherlands: Springer Netherlands.
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11. Webster D. M. (2000). Protein Structure Prediction: Methods and Protocols. Ukraine: Humana Press.
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14. Mishra P. (Serial editor). Blackman J. A. (Editor). Metallic Nanoparticles. (2008). Netherlands: Elsevier Science.
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16. Niemeyer C. M. and Mirkin C. A. (2006). Nanobiotechnology. John Wiley & Sons.
17. Omran B. A. (2020). Nanobiotechnology: A Multidisciplinary Field of Science. Germany: Springer International Publishing.
18. Prashanthi M., Sundaram R., Jeyaseelan A. and Kaliannan T. (Editors). (2021). Bioremediation and Green Technologies: Sustainable approaches to mitigate environmental impacts. Germany: Springer International Publishing. Environmental Science and Engineering. DOI 10.1007/978-3-319-48439-6_11
19. Rai M. and Duran N. (2011). Metal nanoparticles in Microbiology. Springer Verlag Berlin Heidelberg.
20. Schmid G. (Editor). (2006). Nanoparticles: From Theory to Application. Germany: Wiley.
21. Thyagarajan L. P., Sudhakar S. and Meenambal T. (2017). Bioremediation of congo-red dye by using silver nanoparticles synthesized from *Bacillus* sps. © Springer International Publishing AG 2017.

Semester II		
Credit	**PSMRELEP-125A: Practicals based on Bioinformatics and Bio-nanotechnology** **Choice based Optional Practical Paper (Elective)** **Total:2Credits Workload: -30 hrs /credit** **(Total Workload: - 2credits x 30 hrs = 60 hrs in semester)** Course outcome: 4. To learn about application of DNA data bases 5. To get concepts of nanoparticles synthesis 6. To understand techniques of magnification systems	**Lectures**
Credit I	**Bioinformatics** 16S rRNA gene sequencing analysis of bacteria: 1. Isolation, purity checking using A260/A280 ratio and Agarose gel electrophoresis of isolated chromosomal DNA of bacteria 2. Introduction to genomics and proteomics 3. PCR amplification and purification of 16S rRNA gene 4. Demonstration of the following steps, if not possible to perform in your lab: PCR product Sequencing using automated sequencer 5. Sequence matching by BLAST analysis. 6. Genomic match of viral/ bacterial pathogen epitope; web based study	**30**

Credit II	**Bio-nanotechnology** 1. Microbial synthesis of nanoparticles (at least 2 types) using actinomycetes /fungi /yeast 2. Characterization of nanoparticles (UV-VIS Spectroscopy), antimicrobial activity, dye decolorization activity. 3. Biological synthesis of nanoparticles (at least 2 types) using plant material/plant extract: i. Extract preparation ii. Synthesis of nanoparticles iii. Characterization by UV-VIS spectroscopy iv. Antimicrobial activity, dye decolorization activity 4. Nanoparticle characterization and data analysis (data to be obtained from scientific literature) SEM/TEM/AFM images, FTIR scan, DLS, zeta potential, etc.	**30**

Suggested References: PSMRELEP-125A: Practicals based on Bioinformatics and Bio-nanotechnology

Credit I : Bioinformatics

16S rRNA gene sequencing analysis of bacteria:

1. Isolation, purity checking using A260/A280 ratio and Agarose gel electrophoresis of isolated chromosomal DNA of bacteria
   - Kheyrodin H. and Ghazvinian K. (2012). DNA purification and isolation of genomic DNA from bacterial species by plasmid purification system. African Journal of Agricultural Research, 7(3):433-442.
   - Olson N. D. and Morrow J. B. (2012). DNA extract characterization process for microbial detection methods development and validation. BMC research notes. 5. 668.https://doi.org/10.1186/1756-0500-5-668
2. PCR amplification and purification of 16S rRNAgene:

- Giangacomo C., Mohseni M., Kovar L. and Wallace J. G. (2021).Comparing DNA

Extraction and 16S rRNA Gene Amplification Methods for Plant-Associated Bacterial Communities. Phytobiomes Journal. 5(2):190-201

- Rosselli R., Romoli O., Vitulo N., Vezzi A., Campanaro S., de Pascale F., Schiavon R., Tiarca M., Poletto F., Concheri G., Valle G. and Squartini A. (2016). Direct 16S rRNA-seq from bacterial communities: a PCR-independent approach to simultaneously assess microbial diversity and functional activity potential of each taxon. Sci Rep 6. 32165https://doi.org/10.1038/srep32165
- Srinivasan R., Karaoz U., Volegova M., MacKichan J., Kato-Maeda M., Miller S., Nadarajan R., Brodie E. L. and Lynch S. V. (2015). Use of 16S rRNA gene for identification of a broad range of clinically relevant bacterial pathogens. PLoS ONE 10(2): e0117617.https://doi.org/10.1371/journal.pone.0117617

3. Demonstration of the following steps, if not possible to perform in institute laboratory

a) PCR product sequencing using automated sequencer:

- https://www.youtube.com/watch?v=jFCD8Q6qSTM
- https://www.youtube.com/watch?v=8lAVfKbRK3I

b) Sequence matching by BLAST analysis:

- https://www.youtube.com/watch?v=HXEpBnUbAMo
  https://www.youtube.com/watch?v=JKD5laNtwSc

Drawing phylogenetic tree using related sequences (Using standard software like Phylip, Mega etc)

4.a) Phylip:

https://www.youtube.com/watch?v=9mqHkkSLbIw
https://www.youtube.com/watch?v=7t34HU1guiI

4.b) Mega:

https://www.youtube.com/watch?v=wPRCLnF2NYk
https://www.youtube.com/watch?v=encRU80nOHg

Credit II : Bio-nanotechnology

1. Biological synthesis of nanoparticles (at least 2 types) using actinomycetes /fungi /yeast.

- Ranjitha V. R. and Rai V. R. (2017). Actinomycetes mediated synthesis of gold nanoparticles from the culture supernatant of *Streptomyces griseoruber* with special reference to catalytic activity. 3 Biotech. 7(5): 299.doi:10.1007/s13205-017-0930-3

- Sabir S., Zahoor M.A., Waseem M., Siddique M. H., , Shafique M., ImranM.,
- Hayat S., Malik I. R., and Muzammil S. (2020). Biosynthesis of ZnO nanoparticles using *Bacillus subtilis*: characterization and nutritive significance for promoting plant growth in *Zea mays* L. Dose-Response.doi:10.1177/1559325820958911

2. Characterisation of nanoparticles by UV-VIS spectroscopy, Antimicrobial activity and dye decolorization activity (photocatalytic activity)

- San Keskin N. O., Koçberber Kılıç N., Dönmez G. andTekinay T. (2016). Green synthesis of silver nanoparticles using cyanobacteria and evaluation of their photocatalytic and antimicrobial activity. JNanoR. 40: 120–127.https://doi.org/10.4028/www.scientific.net/jnanor.40.120
- Thyagarajan L. P., Sudhakar S. and Meenambal T. (2017). Bioremediation of congo-red dye by using silver nanoparticles synthesized from *Bacillus* sps. © Springer International Publishing AG 2017. M. Prashanthi et al. (eds.), Bioremediation and Sustainable Technologies for Cleaner Environment, Environmental Science and Engineering. DOI10.1007/978-3-319-48439-6_11
- Yehia R. S. and Ali A. M. (2020). Biosynthesis and characterization of iron nanoparticles produced by *Thymus vulgaris* L. and their antimicrobial activity. Acta Botanica Croatica, 79(2). Retrieved from http://www.abc.botanic.hr/index.php/abc/article/view/2724

3.Biological synthesis of nanoparticles (at least 2 types) using plant material/plant extract

- Chand K., Cao D., Fouad D. E., Shah A. H., Dayo A. Q., Zhu K., Lakhan N. M., Mehdi G. and Dong S. (2020). Green synthesis, characterization and photocatalytic application of silver nanoparticles synthesized by various plant extracts. Arabian Journal of Chemistry. 13(11): 8248-8261. https://doi.org/10.1016/j.arabjc.2020.01.009.
- Yasmin S., Nouren S., Bhatti H. N., Iqbal D. N., Iftikhar S., Majeed J., Mustafa R., Nisar N., Nisar J., Nazir A., Iqbal M. and Rizvi H. (2020). “Green synthesis, characterization and photocatalytic applications of silver nanoparticles using Diospyros lotus”. Green Processing and Synthesis. 9(1):87-96. https://doi.org/10.1515/gps-2020-0010

- Nanoparticle characterization data analysis (data to be obtained from scientific literature): SEM/TEM/AFM images, FTIR scan, DLS, zeta potential.:
  - Lin P. C., Lin S., Wang P. C. and Sridhar, R. (2014). Techniques for physicochemical characterization of nanomaterials. Biotechnology

advances, 32(4), 711–726.https://doi.org/10.1016/j.biotechadv.2013.11.006

- Mourdikoudis S., Pallares R. M. and Thanh N. T. K. (2018). Characterization techniques for nanoparticles: comparison and complementarity upon studying nanoparticle properties. Nanoscale. 10; 12871-12934. https://doi.org/10.1039/C8NR02278J
- Santhoshkumar J., Rajeshkumar S. and Venkat Kumar S. (2017). Phyto-assisted synthesis, characterization and applications of gold nanoparticles – A review. Biochemistry and BiophysicsReports. 11: 46-57. https://doi.org/10.1016/j.bbrep.2017.06.004.

	Semester II	
Credit	**PSMRELE-126B: Molecular Biology tools and applications** **Choice based Optional Theory Paper (Elective)** Total: 2 Credits Workload: -15 hrs /credit (Total Workload: - 2 credits x 15 hrs = 30 hrs in semester) Course outcomes: 1. To understand various techniques in DNA studies 2. To gain knowledge about applications of DNA 3. To learn advance techniques in DNA- protein	**Lectures**
Credit I	**Tools in Molecular Biology** 1. Study of protein-DNA interactions: electrophoretic mobility shift assay; DMS foot printing, DNase foot printing; methyl interference assay, protein-protein interactions using yeast two- hybrid 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. Concept of protein microarray	**15**

Credit II	**Applications of recombinant DNA technology in production of :** 1. Synthesis of commercial products: Amino acids (L-Valine and L-cysteine), ascorbic acid, Peptide antibiotics, 2. Hybrid Human-Mouse monoclonal antibodies, Human monoclonal antibodies, anti-cancer antibodies 3. Biopolymers: gum, rubber, polyhydroxyalkanoates. 4. Un-conventional microbial systems for production of high-quality protein drugs	**15**

Suggested ReferencesPSMRELE-126BMolecular Biology tools and applications

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. SpringerUS.
3. Burton D. R., Silverman G. J. and Barbas C. F. (2004). Phage Display: A Laboratory Manual. United States: Cold Spring Harbor LaboratoryPress.
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: HumanaPress.
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 LaboratoryPress.
8. Fu H. (2004). Protein-protein Interactions: Methods and Applications. Ukraine: HumanaPress.
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 & BartlettLearning.

12. Kalia V. C. (2016). Microbial Factories: Biodiversity, Biopolymers, Bioactive Molecules: Volume 2. India: SpringerIndia.
13. Kurnaz I. A. (2015). Techniques in Genetic Engineering. United Kingdom: CRCPress.
14. Leblanc B. and Moss T. (2010). DNA-Protein Interactions: Principles and Protocols. Third Edition. United States: HumanaPress.
15. Lilley D. M. J. and Eckstein F. (2012). Nucleic Acids and Molecular Biology. Germany: Springer Berlin Heidelberg.
LodishH.,BerkA.,KaiserC.A.,KriegerM.,BretscherA.,PloeghH.,AmonA.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 ofChemistry.
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 & BartlettLearning.
21. Stanbury P. F., Whitaker A. and Hall S. J. (2016). Principles of Fermentation Technology. Netherlands: ElsevierScience.
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 UniversityPress.
25. Voet D. and Voet J. G. (2011). Biochemistry. United Kingdom: Wiley. ISBN: 9780470570951
26. Walsh G. (2013). Pharmaceutical Biotechnology: Concepts and Applications.Germany:
16. Wiley.

Semester II

PSMRELEP-126B: : Practical based on Molecular Biology tools and applications

Choice based Optional Practical Paper (Elective)

Total: 2 Credits Workload: -30 hrs /credit

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

Course outcomes:

1. To understand various techniques in DNA analysis
2. To explore about applications of DNA using various tools
3. To learn advance techniques in DNA- protein systems

1. Cloning and transformation using plasmid vectors- GFP gene cloning/ blue and white screening:
   i. Vector and Insert Ligation,
   ii. Preparation of competent cells
   iii. Transformation of *E. coli* with standard plasmids,
   iv. Calculation of transformation efficiency
2. KBASE web server (Gene annotation metabolic modeling)
3. Protoplast fusion
4. Activity staining analysis (Zymograms) (NATIVEPAGE)
5. FTIR analysis of a biomolecule/recombinant molecule (at least five different molecules)
6. Production by recombinant strain and estimation of Biopolymers:
   i. Gum
   ii. Polyhydroxyalkanoates (PHB)

Suggested references

1. Cloning and transformation using plasmid vectors- GFP gene cloning or blue and white screening:

1.a) Green Florescence 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, 30https://doi.org/10.1186/1475-2859-9-30

- Slama R. A. and Ziada A. S. (2016). Initial stages of construction of a plasmid to study the kinetics of gene expression at a single cell level following uptake of DNA into *Escherichia coli*. Journal of experimental microbiology and immunology. (JEMI). 20: 86-91

1.b) Blue and white screening:

Julin D.A. (2018) Blue/White Selection. In: Wells R.D., Bond J.S., KlinmanJ., Masters B.S.S. (eds) Molecular Life Sciences. Springer, New York, NY. https://doi.org/10.1007/978-1-4614-1531-2_94

- Liu J., Chang W., Pan L., Liu X., Su L., Zhangn W., Li Q., and Zheng Y. (2018). An improved method of preparing high efficiency transformation *Escherichia coli* with both plasmids and larger DNA fragments. Indian Journal of Microbiology, 58(4): 448–456.https://doi.org/10.1007/s12088-018-0743-z
- Zhang Y. S. (2016). Blue-white screening liquid can eliminate false positives in blue- whitecolonyscreeningGeneticsandMolecularResearch15(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 rRNA-seq from bacterial communities: a PCR-independent approach to simultaneously assess microbial diversity and functional activity potential of each taxon. Sci Rep 6:32165https://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
- YeJ.,CoulourisG.,ZaretskayaI.,ZaretskayaI.,CutcutacheI.,RozenS.andMadden

  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

5. 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 ofBiological 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/BfcQ8Se5jNz6.b.iii) Ascorbicacid:

- 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

7. Production by recombinant strain and estimation of Biopolymers: 7.i) Gum:

- Dai X., Gao G., Wu M., Wei W., Qu J., Li G. and Ma T. (2019). Construction and application of a *Xanthomonas campestris* CGMCC15155 strain that produces white xanthan gum. Microbiology Open. 8:e631.https://doi.org/10.1002/mbo3.631
- Sukumar S., Arockiasamy S., Moothona M. C. (2021). Optimization of cultural conditions of gellan gum production from recombinant *Sphingomonas paucimobilis* ATCC 31461 and its characterization. Journal of Applied Biology & Biotechnology. 9(1):58-67. DOI:10.7324/JABB.2020.9108

7.ii) Polyhydroxyalkanoates (PHB)

- Li R., Zhang H. and Qi Q. (2007). The production of polyhydroxyalkanoates in recombinant *Escherichia coli*. Bioresource Technology. 98(12): 2313-2320. https://doi.org/10.1016/j.biortech.2006.09.014.
- Nikel P. I., de Almeida, A., Melillo, E. C., Galvagno M. A., and Pettinari M. J. (2006). New recombinant *Escherichia coli* strain tailored for the production of poly (3-hydroxybutyrate) from agroindustrial by-products. Applied and Environmental Microbiology, 72(6), 3949–3954. https://doi.org/10.1128/AEM.00044-06

Semester II		
Credit	**PSMRELE-127C: Nitrogen Metabolism, Respiration and Photosynthesis** **Choice based Optional Theory Paper (Elective)** Total: 2Credits Workload: -15 hrs /credit (Total Workload: - 2credits x 15 hrs = 30 hrs insemester) Course outcomes: 1. To understand importance of Nitrogen in bacterial system 2. To learn energy transfer during respiration 3. To gain insights of energy generation using light in life forms	**Lectures**
Credit I	**Nitrogen Metabolism** 1. Nitrogen cycle, 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 nitrogenous bases	**15**
Credit II	**Respiration and photosynthesis:** 5. 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. 6. Photosynthesis: a) Organization of photosystem I and II, cyclic and non-cyclic flow of electrons, Z scheme, Hill reaction, photolysis of water b) C4, CAM plants, Photorespiration, Regulation of Photosynthesis	**15**

Suggested References: PSMRELE-127C: Nitrogen, Metabolism, Respiration and Photosynthesis

Credit I : Nitrogen Metabolism

1. Blackstock J. C. (2014). Guide to Biochemistry. United Kingdom: ElsevierScience.
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 HealthSciences.
8. Voet D. and Voet J. G. (2011). Biochemistry. United Kingdom:Wiley White D., Drummond J. T., Drummond J. and Fuqua C. (2012).The Physiology and Biochemistry of Prokaryotes. United Kingdom: Oxford UniversityPress.

Credit II : Respiration and Photosynthesis:

1. Doelle H. W. (2014). Bacterial Metabolism. United States: ElsevierScience.
2. Govindjee. (2012). Photosynthesis Volume1. Energy Conversion by Plants and Bacteria. United Kingdom: ElsevierScience.
3. Kim B. H. and Gadd G. M. (2019). Prokaryotic Metabolism and Physiology. United Kingdom: Cambridge UniversityPress.
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. NewYork
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. WoeseC.R.(2004).The archaeal concept and the world it lives in : a retrospective. Photosynthesis Research. 80: 361–372.

Semester II

PSMRELEP-127C: Practicals Based on Nitrogen Metabolism, Respiration and Photosynthesis

Choice based Optional Practical Paper (Elective)

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

Course outcomes:

1. To understand importance of Nitrogen in bacterial system
2. To learn energy transfer during respiration
3. To gain insights of energy generation using light in life forms

1. Isolation of IAA producing organism, Detection of Indole acetic acid production by bacteria
2. Detection of siderophore production by bacteria
3. Enrichment ,Isolation and characterization of nitrogen fixing(free living/symbiotic) activity of bacteria
4. Enrichment, Isolation and characterization of Sulphur reducing bacteria/Methanogens.
5. Enrichment, Isolation and characterization of Cyanobacteria.
6. Seed germination assay / Pot experiment to demonstrate Nitrogen fixing property

Suggested References PSMRELEP-127C: Practicals Based on Nitrogen Metabolism, Respiration and Photosynthesis

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, New York, NY. https://doi.org/10.1007/978-1-0716- 1080-0_47

3. Enrichment, Isolation and characterization of nitrogen fixing activity of 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.
- Pourali A., Afrouziyeh M. and Moghaddaszadeh-ahrabi 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 Danismethod:

- 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.
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