



**M. C. E. Society's**

**Abeda Inamdar Senior College**

Of Arts, Science and Commerce, Camp, Pune- 1

(Autonomous) Affiliated to Savitribai Phule Pune University

NAAC accredited 'A' Grade

**Two Year Degree Program in  
Microbiology (Faculty of Science  
& Technology)**

Syllabus for

M.Sc. (Microbiology)

Part-I

**Choice Based Credit System Syllabus**

**To be implemented from Academic Year 2021-2022**

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

**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, Archaeobacteria, 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)
- **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

In addition, we feel that the students should be well acquainted with research methodology which includes different skill developments in scientific writing, data handling and processing, development of research ideas and planning / designing of research projects. The skill sets thus evolved will help the students in academic and applied research. This syllabus aims to give the student a significant level of theoretical and practical understanding of the subject.

### **Introduction:**

With the changing scenario at local and global level, we feel that the syllabus orientation should be altered to keep pace with developments in the education sector. The need of the hour is proper syllabi that emphasize on teaching of technological as well as the administrative aspects of modern biology. Theory supplemented with extensive laboratory expertise will help these students, to avail these opportunities. Both these aspects i.e., theory and more of practical needs to be stressed, such that a post-graduate student can start work directly in applied fields (industry or institutions), without any additional training.

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

Microbiology curricula are operated at two levels viz. undergraduate and postgraduate. The

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

**Objectives to be achieved:**

- To enrich students' knowledge and train them in the pure microbial sciences
- To introduce the concepts of mathematics in biology
- To inculcate research aptitude
- To inculcate sense of scientific responsibilities and social and environment awareness
- To help students build-up a progressive and successful career in Microbiology

**PROGRAM SPECIFIC OUTCOME**

The Objectives of PG Microbiology are to get students familiarized to versatile tools and techniques employed in genetic engineering and recombinant DNA technology. They are introduced to the concepts of Mathematics in Biology. The objective is to inculcate research aptitude and carry out academic and applied research. They gain significant level of theoretical and practical understanding of recent trends in various fields of Microbiology. They gain an insight on Clinical, Pharmaceutical and Quantitative Microbiology; Molecular biology, Microbial Virus Technology, Molecular Biophysics, Advances in Microbial Technology, Industrial waste water treatment and industrial production of vaccines.

**Evaluation Pattern:**

For each Theory and Practical Course, 50-50 pattern will be followed. Internal assessment will be of 50 marks for a paper of 100 Marks. Internal assessment will be of 25 marks for a paper of 50 Marks. For Continuous Internal Evaluation (CIE), evaluation of theory courses will be done continuously. The 50 marks of Internal Evaluation shall be divided into the following:

- a) One Mid Semester Exams of 15 Marks each
- b) Two Class Tests of 15 marks each converted to 15 Marks
- c) One Presentation/Seminar/MCQ Test of 5 Marks
- d) One Group Discussion/Open Book Test of 5 or 10 Marks
- e) Class Assignments of 10 or 5 Marks
- f) A compulsory Mock Practical Examination and Viva Voce of practical subjects
- g) Internal marks for Journal / project report/ dissertation report completion and certification

Course Structure: Semester I						
Course Type	Course Code	Course Name	Credits	Assessment		
				IA	UE	Total
Core Compulsory Theory Papers	21SMMB111	Microbial Systematics	4	50	50	100
	21SMMB112	Quantitative Biology	4	50	50	100
	21SMMB113	Biochemistry, Enzymology & Cell Biology	4	50	50	100
Choice Based Optional Papers Elective/ Departmental  Course	21SMMB114A	Fungal Systematics and Extremophiles	2	25	25	50
	21SMMB116A	Practicals Based on Fungal Systematics and Extremophiles	2	25	25	50
	OR					
	21SMMB114B	Experimental Design and Quantitative approaches for Biologists	2	25	25	50
	21SMMB116B	Practicals based on Experimental Design and Quantitative approaches for Biologists	2	25	25	50
	OR					
	21SMMB114C	Protein chemistry and membrane transport	2	25	25	50
	21SMMB116C	Practicals Based on Protein chemistry and membrane transport	2	25	25	50
Core Compulsory Practical paper	21SMMB115	Biochemical Techniques (Practicals based on compulsory theory credits)	4	50	50	100

Course Structure: Semester II						
Course Type	Course Code	Course Name	Credits	Assessment		
				IA	UE	Total
Core Compulsory Theory Papers	21SMMB121	Instrumentation and Molecular Biophysics	4	50	50	100
	21SMMB122	Molecular Biology I	4	50	50	100
	21SMMB123	Biomolecules and Clinical Biochemistry	4	50	50	100
Choice Based Optional Papers Elective/ Departmental Course	21SMMB124 A	Bioinformatics and Bio-nanotechnology	2	25	25	50
	21SMMB126 A	Practicals based on Bioinformatics and Bio-nanotechnology	2	25	25	50
	OR					
	21SMMB124B	Molecular Biology tools and applications	2	25	25	50
	21SMMB126B	Practicals based on Molecular Biology tools and applications	2	25	25	50
	OR					
	21SMMB124C	Respiration and Photosynthesis	2	25	25	50
	21SMMB126C	Practicals based on respiration and Photosynthesis	2	25	25	50
Core Compulsory Practical paper	21SMMB125	Molecular biology, metabolism and instrumentation Techniques (Practicals based on compulsory theory credits)	4	50	50	100



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**MSc I Syllabus**  
**Semester I**  
**(CBCS – Autonomy 21 Pattern)**

<b>Course/ Paper Title</b>	Microbial Systematics
<b>Course Code</b>	21SMMB111
<b>Semester</b>	I
<b>No. of Credits</b>	4

**Aims & Objectives of the Course**

<b>Sr. No.</b>	<b>Objectives</b>
<b>1.</b>	To enrich students' knowledge related to basic concepts in Microbial systematics
<b>2.</b>	To inculcate the concepts of culturable and unculturable bacteria
<b>3.</b>	To make students acquainted with the concepts of microbial diversity and evolution

**Expected Course Specific Learning Outcome**

<b>Sr. No.</b>	<b>Learning Outcome</b>
<b>1.</b>	Students will understand the concepts of Microbial systematics
<b>2.</b>	Students will be able to study the diversity and unculturable bacteria and evolution and bacterial systematics
<b>3.</b>	Students will understand the concept and applications of concepts of microbial diversity and evolution

**21SMMB111: Microbial Systematics****Core Compulsory Theory Paper**

Total: 4 Credits

Workload: 15hrs /credit

<b>Credit Number</b>	<b>Credit</b>	<b>Workload</b>
<b>I</b>	<b>Bacterial Systematics</b>	<b>15</b>
	1. Species concept in prokaryotes and eukaryotes 2. 5-Kingdom classification system 3. 3-Domain classification system 4. Determinative Bacteriology (Phenetic Approach) 5. Systematic Bacteriology (Phylogenetic Approach) 6. Polyphasic Approach 7. Molecular clocks, phylogeny and molecular distances The origin of life (chemical and cellular evolution), ribosomal RNA analyses for tracing microbial evolution, genetic basis of evolution, evolution of physiological diversity. Taxonomy, binomial nomenclature, types of bacterial classification systems, new approaches to bacterial taxonomy (numerical taxonomy, ribotyping, rRNA sequencing, fatty acid profile) Bergey's manual of systematic bacteriology. Microbial diversity- molecular chronometers, phylogenetic trees and three domain universal phylogenetic tree.	
<b>II</b>	<b>Microbial Diversity</b>	<b>15</b>
	The expanse of microbial diversity Estimates of total number of species Species Divergence and the measurement of microbial Diversity. Measures and indices of diversity	
<b>III</b>	<b>Exploration of Un-culturable microbial diversity</b>	<b>15</b>
	1. Concept of 'unculturable' bacterial diversity. 2. Strategies for culture of 'unculturable' bacteria. 3. Culture independent molecular methods for identifying unculturable bacteria (PCR, RFLP, ARDRA, DGGE, TGGE, RAPD, Microarray, FISH, RISA) 4. Methods of extracting total bacterial DNA from a habitat and metagenome analysis	
<b>IV</b>	<b>Evolution</b>	<b>15</b>
	1. Evolution of antibiotic Spontaneous mutation controversy, evolution of rates of mutation, types of selection, levels of selection, group selection and selfish gene. 2. Socio-biology, kin selection, evolutionary stability of cooperation, sociality and 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	
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**Suggested References:**

1. Microbial Diversity: Form and Function in Prokaryotes, Published Online: 30 NOV 2007. DOI: 10.1002/9780470750490.ch1 Copyright © 2005 by Blackwell Science Ltd
2. Carl R. Woese. The archaeal concept and the world it lives in: a retrospective. Photosynthesis Research 80: 361 – 372, 2004. Kluwer Academic Publishers.
3. Brown James. Principles of Microbial Diversity. ASM Press ,2014.
4. Ridley Mark (2004). Evolution. Blackwell Science Ltd.
5. Species Divergence and the measurement of microbial diversity. Catherine Lozupone and Rob Knight. FEMS Microbiol. Rev. 32 (2008) 557 – 578.
6. Methods of studying soil microbial diversity. Jennifer Kirk et al, (2004). Journal of Microbiological Methods 58, 169 – 188.
7. Keller M. and Zengler K. (2004) Tapping in to Microbial Diversity. Nature Reviews 2, 141-
8. Pace N. (1997) A Molecular View of Microbial Diversity and the Biosphere, Science, 276, 734-740.
9. Woese C. (1987), Bacterial Evolution. Microbiological Reviews, 221-271.
10. Breed and Buchanan. Bergey's Manual of Determinative Bacteriology. 8th Edition, 1974.
11. Breed and Buchanan. Bergey's Manual of Determinative Bacteriology. 9th Edition, 1982.
12. Breed and Buchanan. Bergey's Manual of Systematic Bacteriology. 2nd Edition, (Volumes. 1 – 5) (2001 – 2003).
13. Sykes, G. and F. A. Skinner (Eds). Actinomycetales: Characteristics and Practical Importance. Society for Applied Bacteriology Symposium Series No. 2, Academic Press. 1973.
14. Jacquelyn G. Black (2013) Microbiology: Principles and Explorations, 6th Edition, John Wiley & Sons, Inc
15. Barnett, H. L. and Hunter, B. B. 1960. Illustrated Genera of Imperfect Fungi. Burgess Publishing Co., Minnesota.



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**(CBCS – Autonomy 21 Pattern)**

<b>Course/ Paper Title</b>	Quantitative Biology
<b>Course Code</b>	21SMMB112
<b>Semester</b>	I
<b>No. of Credits</b>	4

**Aims & Objectives of the Course**

<b>Sr. No.</b>	<b>Objectives</b>
<b>1.</b>	To enrich students' knowledge related to basic concepts in Biostatistics
<b>2.</b>	To inculcate the concepts of testing hypothesis using parametric and non-parametric tests
<b>3.</b>	To make students acquainted with the concepts of probability distributions and their application

**Expected Course Specific Learning Outcome**

<b>Sr. No.</b>	<b>Learning Outcome</b>
<b>1.</b>	Students will understand the concepts of descriptive statistics
<b>2.</b>	Students will be able to test the hypothesis and draw the conclusion from the present data that will help them in research
<b>3.</b>	Students will understand the concept and applications of probability distributions

**21SMMB112 Quantitative Biology**

## Core Compulsory Theory Paper

Total: 4 Credits

Workload: 15hrs /credit

Credit No.	Credit	Workload
<b>I</b>	<b>Descriptive Statistics</b>	<b>15</b>
	1. Fundamental concepts –Sample Statistics and Population parameter, data (qualitative and quantitative data, discrete and continuous series data), data sources, variables, measurement scales (nominal, ordinal, interval and ratio), variability and uncertainty in measurements 2. Measures of central tendency – Mean Mode, median 3. Measures of dispersion – Mean deviation, Standard deviation and Variance 4. Data presentation-Tables and Graphs (Histogram, bar, pie and line) 5. Simple linear Regression and correlation ( <i>significance testing not necessary</i> ) <i>(Sr. No. 1:- only theory questions to be asked in exam. Sr. No. 2 – 5:- only problem solving questions to be asked in exam.)</i>	
<b>II</b>	<b>Inferential Statistics-I</b>	<b>15</b>
	1. Uncertainty: Variation, Probability and inference 2. Central Limit Theorem, Standard deviation of the means standard error and confidence interval 3. The concepts of null hypothesis, alternate hypothesis, Test statistics, P-value significance level, type I and type II errors, one tailed and two tailed tests, degrees of freedom, statistical decision tree Parametric statistical test: Z-test, t-test and F-test <i>(Sr. No 1 – 3:- only theory questions to be asked in exam except Z-test, T-test and F-test.)</i>	
<b>III</b>	<b>Inferential Statistics-II</b>	<b>15</b>
	1. Test of Significance: Chi square test (Goodness of fit and Independence), 2. Comparison of 3 or more samples – ANOVA One way and two way 3. Nonparametric Tests: comparison to parametric tests, Run test, Sign test, Wilcoxon's signed rank test and Mann-Whitney U test,	
<b>IV</b>	<b>Probability and Probability Distribution</b>	<b>15</b>
	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	

**Suggested References:**

1. Irfan Ali Khan and AtiyaKhanum, Fundamentals of Biostatistics. 3rd Ed. Ukaaz, Publications, Hyderabad
2. Norman T.J.Bailey Statistical methods in biology, 3rd Ed. Cambridge University Press
3. Goon, Gupta and Dasgupta Fundamentals of statistics, World Press, Kolkata.Lindgren B.W. Statistical Theory, Macmillan Publishing Co. Inc. 4. Wayne Daniel (2007)
4. Montgomery D.C. Design and analysis of experiments, John Wiley & Sons
5. Stephen Newman, Biostatistical methods in Epidemiology. Wiley Interscience Publication
6. Aviva Petrie and Carolene Sabin, 2005, Medical Statistics at a glance, 2nd Edition, Blackwell
7. Haefner James W. (1996) Modeling Biological Systems: Principles and Applications, Kluwer Academic Publications
8. David Brown & Peter Rothery. Models in biology: Mathematics, statistics, and computing John Wiley & Sons, USA
9. Practical Fermentation Technology Edited by Brian McNeil and Linda M. Harvey 2008 John Wiley & Sons, Ltd. ISBN: 978-0-470-01434-9
10. Bioprocess Engineering Principles by Pauline M. Doran (1995), Elsevier Science & Technology Books, ISBN: 0122208552



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**(CBCS – Autonomy 21 Pattern)**

<b>Course/ Paper Title</b>	Biochemistry, Enzymology & Cell Biology
<b>Course Code</b>	21SMMB113
<b>Semester</b>	I
<b>No. of Credits</b>	4

**Aims & Objectives of the Course**

<b>Sr. No.</b>	<b>Objectives</b>
<b>1.</b>	To introduce the concepts of Nitrogen metabolism and protein chemistry
<b>2.</b>	To make students learn the concepts of Enzymology in depth
<b>3.</b>	To give students the knowledge of cell biology including the concepts of regulation of cell cycle cell death

**Expected Course Specific Learning Outcome**

<b>Sr. No.</b>	<b>Learning Outcome</b>
<b>1.</b>	Students will be acquainted with the concepts metabolic pathways involved in Nitrogen metabolism and protein chemistry
<b>2.</b>	Students will understand the concepts of enzymology with relation to inhibitors, allosterism and two substrate enzyme catalyzed reactions
<b>3.</b>	Students will get the knowledge of cells biology, protein trafficking, cell cycle regulation and cell death

**21SMMB113: Biochemistry, Enzymology & Cell Biology**

## Core Compulsory Theory Paper

Total: 4 Credits

Workload: 15hrs /credit

<b>Credit No.</b>	<b>Credit</b>	<b>Workload</b>
<b>I</b>	<b>Nitrogen metabolism</b>	<b>15</b>
	a. Overview of Nitrogen metabolism b. Biochemistry of biological nitrogen fixation, properties of nitrogenase and its regulation c. Ammonia assimilation, glutamine synthetase, glutamate dehydrogenase, glutamate synthetase, their properties and regulation, d. Biosynthesis of amino acids and its allosteric regulation e. Biosynthesis of nucleotides: De novo pathway and Salvage pathway f. Degradation of purines and pyrimidines g. Enzymes in biosynthesis of nucleotides as targets of chemotherapeutic agents	
<b>II</b>	<b>Protein Chemistry:</b>	<b>15</b>
	a. Peptide linkage, partial double bond nature of peptide bond, Resonance forms of the peptide group, cis/trans isomers of peptide group b. Determination of primary structure of polypeptide (N-terminal, C-terminal determination, methods of sequencing of peptides) Problems based on this topic c. Super-secondary structure of proteins d. Ramachandran plot e. Significance of Metalloprotein, motor proteins and membrane proteins f. Concept of AMP(Antimicrobial peptides)	
<b>III</b>	<b>Enzymology</b>	<b>15</b>
	<b>A. Kinetics of reversible inhibitions:</b> a. Competitive, uncompetitive, non-competitive, substrate inhibition b. Primary and secondary plots, Determination of $K_i$ using secondary plots. c. Significance of inhibitors <b>B. King Altman approach to derive</b> two substrate enzyme catalysed reactions <b>C. Concept of allosterism:</b> positive and negative co-operativity, models of allosteric enzymes (Monod, Wyman and Changuax and Koshland, Nemethy and Filmer model), kinetics of allosteric enzyme, Hill plot, examples of allosteric enzymes and their significance in regulation.	

IV	Cell biology	15
	<p><b>A. Structural organization and function of</b></p> <ul style="list-style-type: none"> <li>a. Endoplasmic Reticulum</li> <li>b. Golgi apparatus</li> <li>c. Nucleus</li> <li>d. Mitochondrion</li> <li>e. Lysosomes</li> <li>f. Peroxisomes</li> </ul> <p><b>B. Protein trafficking among various cellular compartments</b> (by secretory and cytosolic pathway: targeting to secretory vesicles, cell membrane, lysosomes, nucleus, mitochondria and peroxisomes)</p> <p><b>C. Events in cell cycle and Regulation of cell cycle</b></p> <ul style="list-style-type: none"> <li>d. <b>Apoptosis:</b> Intrinsic and Extrinsic pathway</li> </ul>	

**Suggested References:**

1. Nelson D. L. and Cox M. M. (2002) Lehninger's Principles of Biochemistry, 4th edition, Mac MillanWorth Pub. Co. New Delhi.
2. Segel Irvin H. (1997). Biochemical Calculations. 2nd Ed. John Wiley and Sons, NY.
3. Garrett, R. H. and Grisham, C. M. (2004) Biochemistry. 3rd Ed. Brooks/Cole, Publishing Company, California.
4. Donald Voet (Author), Judith G. Voet (2011). Biochemistry, 4th Edition, Kindle Edition
5. Biochemistry by U. Satyanarayan and U. Chakrapani 5<sup>th</sup> edition
6. ENZYMES: Biochemistry, Biotechnology, Clinical Chemistry by Trevor Palmer
7. Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis, 2nd Edition by Robert A. Copeland
8. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. (2002) Molecular Biology of the Cell, 4th edition: Garland Science; New York
9. Metzler David E. (2001) Biochemistry: The chemical Reactions of Living Cells, Volume 1&2, Academic Press California.
10. H. Lodish, A. Berk, C. A. Kaiser, M. Krieger, M. P. Scott, A. Bretscher, H. Ploegh, and P. Matsudaira, (2007) Molecular Cell Biology, Sixth Edition W. H. Freeman and Company, New York, , ISBN-13: 978-0-716-77601-7



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**(CBCS – Autonomy 21 Pattern)**

Course/ Paper Title	Fungal Systematics and Extremophiles
Course Code	21SMMB114 A
Semester	I
No. of Credits	2

**Aims & Objectives of the Course**

Sr. No.	Objectives
1.	To make students aware about the classification of fungi, along with their morphological characteristics.
2.	To make them understand the importance and applications of extremophiles.
3.	To teach them applications of Fungi in various Industries.

**Expected Course Specific Learning Outcome**

Sr. No.	Learning outcome
1.	Students will learn the methods of identification of fungi and to classify them.
2.	They will understand the techniques used for the isolation of extremophiles.
3.	Students will become capable for exploring fungi for industrial use



**21SMMB 114A Fungal Systematics and Extremophiles**

**Choice based Optional Theory Paper (Elective)**

Total: 2 Credits Workload: -15 hrs /credit

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

<b>Credit No.</b>	<b>Credit</b>	<b>Workload</b>
<b>I</b>	<b>Fungal Systematics:</b>	<b>15</b>
	1. Six Classes of Fungi 2. Differentiating characters among different Classes of fungi 3. Importance of morphological characters in fungal differentiation and classification	
<b>II</b>	<b>Extremophiles</b>	<b>15</b>
	1. Enrichment, isolation, classification, properties and application of extremophiles: Thermophiles, Psychrophiles, Halophiles, Acidophiles, Methanogens 2. Adaptation mechanisms of extremophiles	



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**(CBCS – Autonomy 21 Pattern)**

<b>Course/ Paper Title</b>	<b>Fungal Systematics and Extremophiles</b>
<b>Course Code</b>	21SMMB114 A
<b>Semester</b>	I
<b>No. of Credits</b>	2

**Aims & Objectives of the Course**

<b>Sr. No.</b>	<b>Objectives</b>
1.	To make students aware about the classification of fungi , along with their morphological characteristics.
2.	To make them understand the importance and applications of extremophiles.
3.	To teach them applications of Fungi in various Industries.

**Expected Course Specific Learning Outcome**

<b>Sr. No.</b>	<b>Objectives</b>
1.	To make the students understand the methods of identification of fungi and to classify them.
2.	To make them understand the techniques used for the isolation of extremophiles.

**21SMMB116 A Practicals Based on Fungal Systematics and Extremophiles**

**Choice based Optional Practical Paper (Elective)**

Total: 2 Credits Workload: -30 hrs /credit

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

<b>Credit No.</b>	<b>Credit</b>	<b>Workload</b>
<b>I</b>	<b>Fungal Systematics:</b>	<b>30</b>
	1. Isolation and identification of yeasts and saprophytic molds from natural samples. The identification key must be designed for each isolated and identified fungus. Students are expected to isolate at least one Genus from Mold and Yeast each (Varied types of samples should be processed to obtain representative isolate of the groups)	
<b>II</b>	<b>Extremophiles</b>	<b>30</b>
	2. Isolation and identification of the following extremophiles from natural samples: Acidophiles and Halophiles Identification of the bacteria to at least the Genus level using the Bergey's Manuals is expected. The identification key must be designed for each isolated and identified bacterium. Students are expected to isolate at least one Genus from each group. (At least 5 different types of samples should be processed to obtain isolates)	



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<b>Course/ Paper Title</b>	<b>Experimental Design and Quantitative approaches for Biologists</b>
<b>Course Code</b>	21SMMB114B
<b>Semester</b>	I
<b>No. of Credits</b>	2

### **Aims & Objectives of the Course**

<b>Sr. No.</b>	<b>Objectives</b>
<b>1.</b>	To introduce the concepts of research methodology
<b>2.</b>	To make students learn the concepts of mathematical models and their Applications
<b>3.</b>	To make them understand the concepts of epidemiological study and clinical trials

### **Expected Course Specific Learning Outcome**

<b>Sr. No.</b>	<b>Learning Outcome</b>
<b>1.</b>	Students develop an interest in the field of research
<b>2.</b>	They understand the use of mathematical models in biological study
<b>3.</b>	Students understand the concepts and use of epidemiological studies and clinical trials and their application

**21SMMB114B Experimental Design and Quantitative approaches for Biologists****Choice based Optional Theory Paper (Elective)**

Total: 2 Credits Workload: -15 hrs /credit

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

<b>Credit No.</b>	<b>Credit</b>	<b>Workload</b>
<b>I</b>	<b>Designing of Experiments</b>	<b>15</b>
	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 and Plackett Burman) 5. Epidemiological Study designs: Case control, cohort, concurrent, cross-sectional, retrospective/prospective 6. Clinical/field trials-Randomization, Bias removal (Blinding – single & double), controlled and uncontrolled trials	
<b>II</b>	<b>Mathematical approach for Biologists</b>	<b>15</b>
	1. Presentation of experimental data (Tables, graphs and equations) 2. Data Analysis (Trends, Testing mathematical models, Goodness of fit: Least Square Analysis, Linear and Non-linear models) 3. Concept of mathematical model, need, modelling the system of interest, modelling the data Deterministic Vs Stochastic model, Cyclic processes of model construction, verification and Applications	



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**(CBCS – Autonomy 21 Pattern)**

<b>Course/ Paper Title</b>	<b>Practicals Based on Experimental Design and Quantitative approaches for Biologists</b>
<b>Course Code</b>	<b>21SMMB116B</b>
<b>Semester</b>	<b>I</b>
<b>No. of Credits</b>	<b>2</b>

**Aims & Objectives of the Course**

<b>Sr. No.</b>	<b>Objectives</b>
<b>1.</b>	To teach the students to make mock research proposal
<b>2.</b>	To make students learn the concepts of mathematics for biologist and their applications
<b>3.</b>	To make them understand the concepts of survey designing and use of software in statistical analysis

**Expected Course Specific Learning Outcome**

<b>Sr. No.</b>	<b>Learning Outcome</b>
<b>1.</b>	Students become capable of writing a research proposal
<b>2.</b>	It develops the research aptitude in students
<b>3.</b>	Students the application of statistical surveys and use of various software in statistics

**21SMMB116B Practicals based on Experimental Design and Quantitative approaches for Biologists**

**Choice based Optional Practical Paper (Elective)**

Total: 2 Credits Workload: -30 hrs /credit

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

<b>Credit No.</b>	<b>Credit</b>	<b>Workload</b>
<b>I</b>	<b>Practicals based on theory credit Designing of experiments</b>	<b>30</b>
	1. Designing of Mock Research Proposal which includes: a) Title b) Hypothesis	

	<p>c) Review of Literature  d) Methodology (<i>Specify Statistical Methods</i>)  e) Possible outcomes (<i>Statistical Interpretations</i>)  f) References  <i>Scientific writing should be followed for Research proposal</i></p> <p>2. Epidemiological study Proposal (<i>Mini Project</i>)  a) Identification of Problem and Establishing Hypothesis  b) Selection of Design  c) Data Collection  d) Data Analysis  e) Data Presentation  f) Conclusion  <i>Scientific writing should be followed for proposal</i></p> <p>3. Statistical Survey  a) Identification of Problem and Establishing Hypothesis  b) Survey Design (Questionnaire based)  c) Preparation of Questionnaire  d) Data Collection  e) Data Analysis  f) Data Presentation  g) <i>Conclusion of Survey</i>  <i>(Actual statistical survey need to be carried out to demonstrate its mechanism)</i></p> <p>4. Factorial Study Design (Placket barmen, Fractional Factorial and full factorial) for Optimization of Media conditions  a) Data collection from Research Papers/ Dissertations /Journals  b) Data Treatment using Statistical Software's (Mini tab, SPSS and Design Expert)  <i>(Sr. no. 1 is compulsory, select any one from Sr. no.2 to 4)</i></p>	
<b>II</b>	<b>Practicals based on theory credit Mathematical approach for Biologists</b>	<b>30</b>
	<p>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</p> <p>2. Computer applications: Using data sheets, and sorting data with different parameters, plotting graphs – bar charts, line graphs, pie charts, adding error bars. (<i>Using Statistical Packages other than Microsoft Excel</i>)</p> <p>3. Statistical analysis of data – Students t test, ANOVA, Chi square test, F test using computer software(<i>Using Statistical Packages other than Microsoft Excel</i>)</p>	



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**(CBCS – Autonomy 21 Pattern)**

<b>Course/ Paper Title</b>	Protein Chemistry and Membrane transport
<b>Course Code</b>	21SMMB 114C
<b>Semester</b>	I
<b>No. of Credits</b>	2

### **Aims & Objectives of the Course**

<b>Sr. No.</b>	<b>Objectives</b>
<b>1.</b>	To make students acquainted with the concept of Membrane transport and signal Transduction
<b>2.</b>	To inculcate various concepts of protein purification
<b>3.</b>	To teach them to establish protein purification chart

### **Expected Course Specific Learning Outcome**

<b>Sr. No.</b>	<b>Learning Outcome</b>
<b>1.</b>	Students understand the concepts of membrane transport and signal transduction with reference to signaling molecules and machinery
<b>2.</b>	Students understand the protein purification techniques and their application
<b>3.</b>	Students become able to establish enzyme purification chart and check purity of enzyme and efficiency of the process

### **21SMMB 114C Protein Chemistry and Membrane transport**

#### **Choice based Optional Theory Paper (Elective)**

Total: 2 Credits Workload: -15 hrs /credit

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

<b>Credit No.</b>	<b>Credit</b>	<b>Workload</b>
<b>I</b>	<b>Membrane transport and signal transduction</b>	<b>15</b>
	The composition and architecture of membranes, Membrane dynamics,	



	<p>Solute transport across membranes: Passive diffusion, facilitated transport, primary and secondary active transport using P, V and F type ATPases, Ionophores, Ion mediated transport, transport of ions across membranes (ion pumps), ligand and voltage gated ion channels,</p> <p>Liposomes and model membranes,</p> <p>Signal transduction pathways in bacteria, second messengers, regulation of signaling pathways, bacterial two-component systems, chemotaxis.</p>	
<b>II</b>	<b>Protein Purification and synthesis</b>	<b>15</b>
	<ol style="list-style-type: none"> <li>1. Cell disruption</li> <li>2. Chromatographic methods</li> <li>3. Electrophoresis</li> <li>4. Chemical synthesis of peptides and proteins</li> <li>5. Purification of proteins</li> <li>6. Purification chart</li> </ol>	



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**(CBCS – Autonomy 21 Pattern)**

<b>Course/ Paper Title</b>	Practicals based on Protein chemistry and membrane transport
<b>Course Code</b>	21SMMB116C
<b>Semester</b>	I
<b>No. of Credits</b>	2

**Aims & Objectives of the Course**

<b>Sr. No.</b>	<b>Objectives</b>
<b>1.</b>	To make students study the concepts of osmosis and diffusion using artificial membranes
<b>2.</b>	To learn the to disrupt the microbial cells using various techniques
<b>3.</b>	To teach them calculations of enzyme activity, specific activity and establish enzyme purification chart

**Expected Course Specific Learning Outcome**

<b>Sr. No.</b>	<b>Learning Outcome</b>
<b>1.</b>	Students understand the concepts of diffusion and osmosis practically using artificial membranes and can relate to biological membranes
<b>2.</b>	Students learn to disrupt the microbial cells and purify the enzymes
<b>3.</b>	Students can establish the enzyme purification chart and check efficiency of purification process

**21SMMB116CPracticals based on Protein chemistry and membrane transport**

**Choice based Optional Practical Paper (Elective)**

Total: 2 Credits Workload: -30 hrs /credit

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

<b>Credit No.</b>	<b>Credit</b>	<b>Workload</b>
<b>I</b>	<b>Membrane transport and signal transduction</b>	<b>30</b>
	Study principles of osmosis and diffusion using artificial membranes (dialysis membrane) (explain how various physical and chemical factors affect the diffusion) Different methods of cell disruption. Swab evaluation with respect to transport of bacterial sample.	
<b>II</b>	<b>Protein Purification and synthesis</b>	<b>30</b>
	Protein purification (Amylase/ Invertase) using salt/ solvent precipitation Purification and establishment of purification chart	



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**(CBCS – Autonomy 21 Pattern)**

<b>Course/ Paper Title</b>	<b>Biochemical Techniques Core Compulsory Practical Paper</b>
<b>Course Code</b>	21SMMB115
<b>Semester</b>	I
<b>No. of Credits</b>	4

### **Aims & Objectives of the Course**

<b>Sr. No.</b>	<b>Objectives</b>
1.	To make students aware about SOPs of various instruments
2.	To make them familiar with different enzyme assays
3.	To teach them applications of computer

### **Expected Course Specific Learning Outcome**

<b>Sr. No.</b>	<b>Objectives</b>
1.	Students will learn about preparation of biofertilizers and buffers
2.	Students will learn to isolate and identify organisms
3.	Students will be acquainted with production and purification of enzymes

**21SMMB115: Biochemical Techniques Core Compulsory Practical Paper**

**Core Compulsory Practical Paper**

**Total: 4 Credits Workload: -30 hrs /credit**

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

1. Disposal of chemicals and cultures, recording of scientific experiments. Standardization of laboratory procedures, calibration and validation of instruments and preparing / designing SOP for the same, maintenance of instruments.

2. Buffer: Determination of pKa of a monoprotic weak organic acid; pI

3. Computer applications: Using data sheets, and sorting data with different parameters, plotting graphs – bar charts, line graphs, pie charts, adding error bars. (Using Microsoft Excel) Statistical analysis of data – Students t test, ANOVA, Chi square test, F test using computer software (Using Microsoft Excel)

4. Enrichment, Isolation and identification of the extremophiles from natural samples: Alkaliphiles and Thermophiles.

Identification of the bacteria to at least the Genus level using the Bergey's Manuals. The identification key must be designed for each isolate.

11. Preparation of bio fertilizer

12. Production, purification and quantification of bacterial/ fungal amylase/ protease.

7. Enzyme assay:

a) Determination of  $K_m$  and  $V_m$  of purified enzyme.

b) To assess effect of pH on enzyme activity.

c) To assess effect of enzyme conc.

d) To assess temperature stability of the enzyme.

e) To assess effect of activator on enzyme activity.

f) To assess effect of inhibitor on enzyme activity

8. Colorimetry and spectrophotometry: Estimation of above extracted sample: UV Spectrophotometry (purity using A280 method).

9. Ion Exchange Chromatography of Protein

10. Electrophoresis: SDS-PAGE of above extracted proteins / To determine the ion-exchange

capacity and nature of given resin using anion exchange chromatography.

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



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## Semester II

(CBCS – Autonomy 21 Pattern)

<b>Course/ Paper Title</b>	<b>Instrumentation and Molecular Biophysics</b>
<b>Course Code</b>	21SMMB121
<b>Semester</b>	II
<b>No. of Credits</b>	4

### Aims & Objectives of the Course

<b>Sr. No.</b>	<b>Objectives</b>
<b>1.</b>	To enrich students' knowledge related to basic concepts in Instrumentation and Molecular Biophysics
<b>2.</b>	To inculcate the concepts of instrumentation including FTIR, NMR and X-Rays
<b>3.</b>	To make students acquainted with the concepts of biophysics and instrumentation

### Expected Course Specific Learning Outcome

<b>Sr. No.</b>	<b>Learning Outcome</b>
<b>1.</b>	Students will understand the concepts of Instrumentation and Molecular Biophysics
<b>2.</b>	Students will be able to understand both fundamentals and applications of the instruments that are routinely used for the characterization of biomolecules.
<b>3.</b>	Students will understand the concept and applications of instruments

**21SMMB121: Instrumentation and Molecular Biophysics**

Total: 4 Credits

Workload: -15 hrs /credit

<b>Credit No.</b>	<b>Credit</b>	<b>Workload</b>
<b>I</b>	<b>Separation and analysis of biomolecules</b>	<b>15</b>
	1. Techniques for sample preparation: Dialysis, ultra-filtration, centrifugal vacuum concentration 2. Chromatography- Partition Coefficient, Selectivity, Resolution, Column Efficiency, Van Deemter equation, Interpretation of chromatograms, Principle, instrumentation and applications of High-Performance Liquid Chromatography (HPLC), Fast Protein Liquid Chromatography (FPLC), Supercritical Fluid Chromatography, Reversed Phase Chromatography and Gas chromatography. 3. Electrophoresis Methods: Pulse field gel electrophoresis, capillary electrophoresis, isoelectric focusing, 2-dimensional electrophoresis, immune-electrophoresis	
<b>II</b>	<b>Spectroscopy</b>	<b>15</b>
	Introduction: Electromagnetic spectrum, Atomic orbitals, Molecular orbitals, Electronic, Rotational and Vibrational transitions in spectroscopy, Interpretation of spectra. 1. UV/Visible spectroscopy- Instrumentation, Molar Absorptivities, Beer and Lamberts Law, Bathochromic and hypochromic shifts. 2. Fluorescence spectroscopy- Instrumentation, Quantum Yield, Quenching, FRET, Binding and Folding studies, Flow cytometry and FACS 3. Infrared spectroscopy- Principle, Instrumentation, Absorption bands, FTIR and its applications 4. Mass spectroscopy- Principles of operation, Ionization, Ion fragmentation, Mass Analysers, GC-MS, MALDI-TOF	
<b>III</b>	<b>Biophysical Techniques</b>	<b>15</b>
	1. NMR spectroscopy: Basic Principles of NMR, Chemical shift, Intensity, Line width, Relaxation parameters, Spin coupling, Nuclear Overhauser Effect Spectroscopy, Correlation Spectroscopy, Approach to structure determination by 2D-NMR 2. X-ray crystallography: Purification of proteins, Crystallization of proteins, Instrumentation, acquisition of the diffraction pattern, basic principles of x-ray diffraction, Crystal Structures (Bravais Lattices), Crystal planes and Miller Indices, Fourier Transform and Inverse Fourier, Direct Lattice	
<b>IV</b>	<b>Gene sequencing</b>	<b>15</b>



	<p>Objectives of gene sequencing</p> <p>Challenges in gene sequencing</p> <p>Vectors used in gene sequencing</p> <p>Outline of gene sequencing procedures like</p> <p>Maxam Gilbert's method, Sanger's method, Pyrosequencing, Ion torrent</p> <p>Isolation of DNA</p> <p>Amplification of DNA by PCR</p> <p>Gel electrophoresis</p> <p>Automated Sequencer</p> <p>BLAST analysis</p> <p>DNA-DNA Hybridization methods</p> <p>Strategies for whole genome sequencing</p> <p>Whole Genome Shotgun Sequencing</p> <p>Applications of gene sequencing (identification of organisms)</p>	
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### Suggested References:

1. Wilson Keith and Walker John (2005) *Principles and Techniques of Biochemistry and Molecular Biology*, 6th Ed. Cambridge University Press, New York.
2. Rolf Ekman, Jerzy Silberring, Ann Westman-Brinkmalm, Agnieszka Kraj (2009) *Mass spectrometry: instrumentation, interpretation, and applications*, John Wiley & Sons, Inc., Canada.
3. Irwin H. Segel (1976) *Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry*, 2nd Edition. John Wiley & Sons.
4. Mount, D. W. (2001) *Bioinformatics: sequence and genome analysis*. Cold Spring Harbor Laboratory Press, New York.
5. David M Webster (2000) *Protein Structure Prediction-Methods and Protocols*, Methods In Molecular Biology Vol 143 Humana Press.
6. Narayanan, P. (2000) *Essentials of Biophysics*. New Age International Publication, New Delhi.
7. Clive Dennison (2002) *A guide to protein isolation*, Kluwer Academic Publishers
8. Pattabhi, V. and Gautham, N. (2002) *Biophysics*. Kluwer Academic Publishers, New York and Narosa Publishing House, Delhi.
9. David J Holme, Hazel Peck (1998) *Analytical Biochemistry*, 3rd Ed. Prentice Hall, Pearson Education Limited, Harlow England.
10. Rodney F. Boyer (2000) *Modern Experimental Biochemistry* 3rd edition., Benjamin Cummings.
11. Nölting, B. (2006) *Methods in modern biophysics*. Second Edition. Springer, Germany.
12. Chakravarty, R., Goel, S., & Cai, W. (2014). Nanobody: The "Magic Bullet" for Molecular Imaging? *Theranostics*, 4(4), 386-398. doi:10.7150/thno.8006.
13. Christof M. Niemeyer and Chad A. Mirkin (2006) *Nanobiotechnology*, John Wiley & Sons.
14. Daniel L. Feldheim and Colby A. Foss, Jr. (2002) *Metal nanoparticles synthesis and characterization and applications* Marcel Dekker, Inc.
15. Mahendra Rai and Nelson Duran (2011) *Metal nanoparticles in Microbiology*, Springer Verlag Berlin Heidelberg



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**(CBCS – Autonomy 21 Pattern)**

<b>Course/ Paper Title</b>	<b>Molecular Biology I</b>
<b>Course Code</b>	21SMMB122
<b>Semester</b>	II
<b>No. of Credits</b>	4

**Aims & Objectives of the Course**

<b>Sr. No.</b>	<b>Objectives</b>
1.	To make students aware about genomics and proteomics
2.	To make them familiar with various techniques used for molecular diagnostics
3.	To teach them applications of molecular techniques

**Expected Course Specific Learning Outcome**

<b>Sr. No.</b>	<b>Objectives</b>
1.	Students will learn about proteomics and its applications
2.	Students will learn about genomics and its applications
3.	Students will be acquainted with the latest molecular biology techniques and their applications

**21SMMB 122 Molecular Biology I**

Total: 4 Credits

Workload: -15 hrs /credit

<b>Credit</b>	<b>Credit</b>	<b>Workload</b>
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No.		
<b>I</b>	<b>Genomics</b>	<b>15</b>
	A. Gene sequencing, conserved genes, finding base sequences which form genes B. Many proteins from one gene, alternative gene expression: DNA imprinting and Epigenetics C. Genomic variation-SNPs, SNPS and diseases, SNPS detection and medical therapies. Eukaryotic and prokaryotic SNPs D. Role of genomic variation in aging, Recognition of trades offs associated with genomic variation	
<b>II</b>	<b>Proteomics</b>	<b>15</b>
	a) Basic concept of proteomics b) Expression, Analysis and Characterization of Proteins c) Analysis of protein structure d) Protein interaction. e) Basic concept of Metabolomics with examples and global biochemical networks	
<b>III</b>	<b>Mobile DNA elements</b>	<b>15</b>
	Transposable elements in bacteria, IS elements, composite transposons, Integrons. Replicative, nonreplicative transposons, and Mu transposition Controlling elements in Tn A, Tn 5 and Tn 10 transposition Transposons in maize and Drosophila Retroviruses and retrotransposon, Ty elements in yeasts SINES, LINES and Alu elements. Significance of transposons and Integrons.	
<b>IV</b>	<b>Molecular diagnostics and applications</b>	<b>15</b>
	Protein arrays to detect polygenic diseases, Immunoassay for protein confirmation-specific disorders Detection of diseases-associated changes in gene expression using microarray Detection of RNA signatures of Antibiotic Resistance in Bacteria Detection of miRNA signatures of Cancer	

### Suggested References

1. Benjamin Lewin. (2008) *Genes IX*, Jones and Bartelett Publishers Inc.
2. S.B Primrose and R M Twyman 2006 7th edition. Blackwell publishing
3. James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann,
4. Michael Levine, Richard Loswick (2004) *Molecular Biology of the Gene*, 5th Edition, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc.
5. Molecular Biology of the Cell, Bruce Albert et. al., 6th Ed., Garland Sciences.
6. Molecular Biology, Lodish et. al., 7th Edn, W. H. Freeman, 2012
7. Weaver R., (2007) *Molecular Biology*, 4th Edition, McGraw Hill Science

8. B.R.Glick,J.J Pasternak J. J. (1998) Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington D C, ASM Press. 3<sup>rd</sup> Ed
9. Genomes. 2nd edition, Brown TA, Oxford: Wiley-Liss; 2002
10. Gene Therapy Tools and Potential Applications- Francisco Martin Molina (2013) JanezaTrdine 9, 51000 Rijeka, Croatia (online book)
11. Worgall S. and R. G. (2014) Gene Therapy In: Principles of Tissue Engineering (Fourth Edition). Academic Press: United States. Chapter 34. 657-686.
12. Maghari B. M. and Ardekani A.M. (2011) Genetically modified foods and social concerns. Avicenna J Med Biotechnol. 3(3):109-17.
13. Ormandy E.H., Dale J. and Griffin G. (2011) Genetic engineering of animals: ethical issues, including welfare concerns. Can Vet J. 52(5):544-50.
14. <http://onlinelibrary.wiley.com/doi/10.1576/toag.12.1.037.27556/>
15. <http://www.nature.com/nrg/journal/v13/n7/full/nrg3230.html>
16. <http://www.ncbi.nlm.nih.gov/pubmed/20920744>



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**(CBCS – Autonomy 21 Pattern)**

<b>Course/ Paper Title</b>	<b>Biomolecules and Clinical Biochemistry</b>
<b>Course Code</b>	21SMMB123
<b>Semester</b>	II
<b>No. of Credits</b>	4

**Aims & Objectives of the Course**

<b>Sr. No.</b>	<b>Objectives</b>
<b>1.</b>	To make students understand the regulatory pathways in Metabolism
<b>2.</b>	To inculcate the concepts of antimicrobial resistance mechanisms in bacteria with emphasis on their signaling pathways
<b>3.</b>	To give students the knowledge of microvirulane in bacteria, virus and fungi

**Expected Course Specific Learning Outcome**

<b>Sr. No.</b>	<b>Learning Outcome</b>
<b>1.</b>	Students will possess the knowledge of the regulation of Metabolism
<b>2.</b>	Students will understand the antimicrobial resistance mechanisms in bacteria with emphasis on their signaling pathways
<b>3.</b>	Students will be acquainted with the concepts of microvirulane in bacteria, virus and fungi

**21SMMB123 Biomolecules and Clinical Biochemistry**

## Core Compulsory Theory Paper

Total: 4 Credits

Workload: 15hrs /credit

<b>Credit No.</b>	<b>Credit</b>	<b>Workload</b>
<b>I</b>	<b>Regulation of Carbohydrate, Protein and Lipid Metabolism</b>	<b>15</b>
	<b>Regulation of Carbohydrate Metabolism:</b> <ol style="list-style-type: none"> <li>Glycogenesis</li> <li>Glycogenolysis</li> <li>Glycolysis</li> <li>Gluconeogenesis</li> <li>TCA</li> <li>ETC</li> </ol> <b>Regulation of Lipid Metabolism:</b> <ol style="list-style-type: none"> <li>Fatty acid synthesis</li> <li>Beta oxidation</li> </ol> <b>Regulation of Protein Metabolism:</b> <ol style="list-style-type: none"> <li>Urea cycle</li> </ol> <b>Central metabolic pathway</b>	
<b>II</b>	<b>Communication in prokaryotic and eukaryotic system</b>	<b>15</b>
	<b>A. Communication and coordination in prokaryotes</b> <ol style="list-style-type: none"> <li>Life cycle and Molecular mechanism of quorum sensing in Myxobacteria</li> <li>Quorum sensing in Gram positive (<i>Staphylococcus aureus</i> virulence factors) and Gram-negative bacteria (<i>Vibrio fischeri</i> lux operon)</li> <li>Secretory systems in bacteria, competence development, sporulation</li> </ol> <b>B. Communication and coordination in eukaryotes</b> <ol style="list-style-type: none"> <li>Life cycle and Molecular mechanism of quorum sensing in <i>Dyctiostelium discoideum</i>.</li> <li>Signaling in higher eukaryotes: autocrine, paracrine, endocrine, neurotransmitters</li> <li>Pathways in cell signaling: GPCRs- <ol style="list-style-type: none"> <li>Adenylate cyclase pathway</li> <li>Regulation of cytosolic <math>Ca^{2+}</math></li> </ol> </li> </ol>	
<b>III</b>	<b>Antimicrobial resistance mechanisms in Bacteria</b>	<b>15</b>
	Antimicrobial resistance mechanisms in Bacteria with respect to: <ol style="list-style-type: none"> <li>Biofilm</li> <li>Efflux Pump</li> <li>Alteration in target site</li> <li>Inactivation of enzyme</li> </ol>	

	5. Alternative pathway or enzyme 6. Formation of persister cells Special emphasis on ESKAPE group of pathogens and <i>Mycobacterium Tuberculosis</i>	
<b>IV</b>	<b>Mechanisms of microbial virulence</b>	<b>15</b>
	Regulation of Bacterial Virulence – Sigma factor and two component system Regulation of Viral Virulence- Viral adhesins, antigenic variation in viruses Regulation of Fungal Virulence	

### References:

1. Nelson D. L. and Cox M. M. (2002) Lehninger's Principles of Biochemistry, 4th edition, Mac Millan Worth Pub. Co. New Delhi.
2. Segel Irvin H. (1997). Biochemical Calculations. 2nd Ed. John Wiley and Sons, NY.
3. Garrett, R. H. and Grisham, C. M. (2004) Biochemistry. 3rd Ed. Brooks/Cole, Publishing Company, California.
4. Donald Voet (Author), Judith G. Voet (2011). Biochemistry, 4th Edition, Kindle Edition
5. Biochemistry by U. Satyanarayan and U. Chakrapani 5<sup>th</sup> edition
6. Toole 'O' George, H. B. Kaplan, R. Kolter, (2000) Biofilm formation as microbial development Annual Review of Microbiology, Vol. 54, 49-79 4.
7. Melissa B. Miller and Bonnie L. Bassler (2001) Quorum sensing in bacteria. Annu. Rev. Microbiol. Vol. 55, 165–99.
8. Christopher M. Waters and Bonnie L. Bassler (2005) Quorum sensing: cell-to-cell communication in bacteria. Annu. Rev. Cell Dev. Biol. Vol. 21, 319–346.
9. Alternative Sigma Factors and Their Roles in Bacterial Virulence Mark J. Kazmierczak, Martin Wiedmann, and Kathryn J. Boor\* MICROBIOLOGY AND MOLECULAR BIOLOGY REVIEWS, Dec. 2005, p. 527–543
10. Common strategies for antigenic variation by bacterial, fungal and protozoan pathogens Kirk W. Deitsch, Sheila A. Lukehart, and James R. Stringer Nat Rev Microbiol. 2009 July ; 7(7): 493–503. doi:10.1038/nrmicro2145.



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**(CBCS – Autonomy 21 Pattern)**

<b>Course/ Paper Title</b>	<b>Bioinformatics and Bio-nanotechnology</b>
<b>Course Code</b>	21SMMB124A
<b>Semester</b>	II
<b>No. of Credits</b>	2

**Aims & Objectives of the Course**

<b>Sr. No.</b>	<b>Objectives</b>
1.	To make students understand the Bioinformatics
2.	To inculcate the concepts of bionanotechnology
3.	To give students the knowledge of Bio-nanotechnology and Bioinformatics

**Expected Course Specific Learning Outcome**

<b>Sr. No.</b>	<b>Learning Outcome</b>
1.	Students will possess the knowledge of Bioinformatics
2.	Students will understand Bio-nanotechnology
3.	Students will be acquainted with the concepts of Bio-nanotechnology and Bioinformatics



**21SMMB124A: Bioinformatics and Bio-nanotechnology****Choice based Optional Theory Paper (Elective)**

Total: 2 Credits Workload: -15 hrs /credit

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

<b>Credit No.</b>	<b>Credit</b>	<b>Workload</b>
<b>I</b>	<b>Bioinformatics</b>	<b>15</b>
	1. Introduction and biological databases Nucleic acid, proteins, genomes— structure data bases, search engines, sequence data forms and submission tools, scoring matrices for sequence alignments, algorithms pairwise sequence alignments, database similarity searches-BLAST, FASTA 2. Gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques, Multiple sequence alignment, phylogenetic analysis and tree building methods, motif searches, epitope prediction, data mining tools and applications, promoter and gene prediction, comparative analysis 3. Demonstration of databases (GENBANK, PDB, OMIM) and software (RASMOL, Ligand Explorer)	
<b>II</b>	<b>Techniques in Bio-nanotechnology</b>	<b>15</b>
	1. Biogenic nanoparticles – Synthesis and applications. Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Role of plants in nanoparticle synthesis. 2. Significance of the physical properties of nanoparticles 3. Characterization of nanoparticles Dynamic Light Scattering (DLS), EDAX analysis, Zeta analysis 4. Imaging techniques to characterize nanoparticles: Principle, instrumentation and applications of TEM (Transmission Electron Microscope) SEM (Scanning Electron Microscope)	



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Of Arts, Science and Commerce, Camp, Pune- 1

(Autonomous) Affiliated to Savitribai Phule Pune University

NAAC accredited 'A' Grade

**(CBCS – Autonomy 21 Pattern)**

<b>Course/ Paper Title</b>	<b>Practicals based on Bioinformatics and Bio-nanotechnology</b>
<b>Course Code</b>	21SMMB126A
<b>Semester</b>	II
<b>No. of Credits</b>	2

### **Aims & Objectives of the Course**

<b>Sr. No.</b>	<b>Objectives</b>
1.	To make students understand the Bioinformatics
2.	To inculcate the concepts of bionanotechnology
3.	To give students the knowledge of Bio-nanotechnology and Bioinformatics

### **Expected Course Specific Learning Outcome**

<b>Sr. No.</b>	<b>Learning Outcome</b>
1.	Students will possess the knowledge of Bioinformatics
2.	Students will understand Bio-nanotechnology
3.	Students will be acquainted with the concepts of Bio-nanotechnology and Bioinformatics

**21SMMB126A: Practical based on Bioinformatics and Bio-nanotechnology**

**Choice based Optional Practical Paper (Elective)**

Total: 2 Credits Workload: -30 hrs /credit

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

Credit No.	Credit	Workload
<b>I</b>	<b>Bioinformatics</b>	<b>30</b>
	16S rRNA gene sequencing analysis of bacteria: <ul style="list-style-type: none"> <li>Isolation, purity checking using A260/A280 ratio and Agarose gel electrophoresis of isolated chromosomal DNA of bacteria</li> <li>Demonstration of the following steps, if not possible to perform in your lab: PCR product Sequencing using automated sequencer</li> </ul>	
<b>II</b>	<b>Bionanotechnology</b>	<b>30</b>
	1. Biological synthesis of nanoparticles (at least 2 types) using <b>actinomycetes /fungi /yeast</b> and their characterization by UV-Vis spectroscopy Characterisation of nanoparticles, Antimicrobial activity, dye decolorization activity, etc 2. Biological synthesis of nanoparticles(at least 2 types) using <b>plant material/plant extract</b> <input type="checkbox"/> Extract preparation <input type="checkbox"/> Synthesis of nanoparticles <input type="checkbox"/> Characterization by UV-Vis spectroscopy, Characterization of nanoparticles, Antimicrobial activity, dye decolorization activity, etc 3. Nanoparticle characterization data analysis(data to be obtained from scientific literature) 4. SEM/TEM/AFM images,FTIR scan, DLS,zeta potential, etc.	



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<b>Course/ Paper Title</b>	<b>Molecular Biology tools and applications</b>
<b>Course Code</b>	21SMMB124B
<b>Semester</b>	II
<b>No. of Credits</b>	2

**Aims & Objectives of the Course**

<b>Sr. No.</b>	<b>Objectives</b>
1.	To make students aware about Recombinant DNA Technology
2.	To make them familiar with various techniques used for molecular diagnostics
3.	To teach them applications of molecular techniques

**Expected Course Specific Learning Outcome**

<b>Sr. No.</b>	<b>Objectives</b>
1.	Students will learn about Recombinant DNA Technology
2.	Students will learn about applications of recombinant DNA Technology
3.	Students will be acquainted with the latest molecular biology techniques and their applications

**21SMMB124B: 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)**

<b>Credit No.</b>	<b>Credit</b>	<b>Workload</b>
<b>I</b>	<b>Tools and techniques in Molecular Biology</b>	<b>15</b>
	<ol style="list-style-type: none"> <li>1. Study of protein-DNA interactions: electrophoretic mobility shift assay; DMS foot printing, DNase foot printing; methyl interference assay and its modifications, nested PCR, Hot start PCR, RT –PCR and Real time PCR (Q –PCR) Applications of PCR.</li> <li>2. DNA microarray, Construction of microarrays – genomic arrays, cDNA arrays and oligo arrays. Applications of microarray</li> <li>3. Super shift assay, Sequence tagged sites, Filter binding assay, Protein foot printing, finding the replicon, DNA fingerprinting, Measuring transcription rates</li> <li>4. Hybridization techniques: Free solution, membrane based (DOT blot, SLOT blot).</li> <li>5. CRISPR-Cas system: Technology and Applications</li> </ol>	
<b>II</b>	<b>Applications of recombinant DNA technology</b>	<b>15</b>
	<p>Application of RDT in Production of Secondary Metabolites</p> <ol style="list-style-type: none"> <li>1. Synthesis of commercial products: Amino acids (L-Valine and L-cysteine), ascorbic acid, Polyketide antibiotics,</li> <li>2. Hybrid Human-Mouse monoclonal antibodies, Human monoclonal antibodies, anticancer antibodies</li> <li>3. Biopolymers: gum, rubber, polyhydroxyalkanoates.</li> <li>4. Un-conventional microbial systems for production of high-quality protein drugs.</li> </ol>	



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<b>Course/ Paper Title</b>	<b>Practical Based on Molecular Biology tools and applications</b>
<b>Course Code</b>	21SMMB126B
<b>Semester</b>	II
<b>No. of Credits</b>	2

### **Aims & Objectives of the Course**

<b>Sr. No.</b>	<b>Objectives</b>
1.	To make students aware about transformation
2.	To make them familiar with various techniques used for molecular diagnostics
3.	To teach them applications of molecular techniques

### **Expected Course Specific Learning Outcome**

<b>Sr. No.</b>	<b>Objectives</b>
1.	Students will learn about blue white screening and GFP
2.	Students will learn about molecular biology recent techniques
3.	Students will be acquainted with the latest molecular biology techniques and their applications

**SMMB126B: Practical Based on Molecular Biology tools and applications****Choice based Optional Practical Paper (Elective) Total: 2 Credits Workload: -30 hrs****/credit (Total Workload: - 2 credits x 30 hrs = 60 hrs in semester)**

<b>Credit No.</b>	<b>Credit</b>	<b>Workload</b>
<b>I</b>	<b>Cloning and transformation using plasmid vectors- GFP gene cloning /blue and white screening</b>	<b>30</b>
	Vector and Insert Ligation, Preparation of competent cells Transformation of E. coli with standard plasmids Calculation of transformation efficiency	
<b>II</b>	<b>PCR amplification and purification of 16S rRNA gene</b>	<b>30</b>
	PCR Primer Design 4. Protoplast fusion 5. Activity staining analysis (Zymograms) (NATIVE PAGE) 6. FTIR analysis of a biomolecule/recombinant molecule (at least five different molecules) 7. Production by recombinant strain and estimation of Biopolymers: a) Gum b) Poly hydroxyalkanoates (PHB)	



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**(CBCS – Autonomy 21 Pattern)**

<b>Course/ Paper Title</b>	Microbial respiration, Photosynthesis and developmental Biology
<b>Course Code</b>	21SMMB124C
<b>Semester</b>	II
<b>No. of Credits</b>	2

**Aims & Objectives of the Course**

<b>Sr. No.</b>	<b>Objectives</b>
<b>1.</b>	To make students study the concepts of anaerobic respiration
<b>2.</b>	To learn the organization and mechanism of photosynthesis
<b>3.</b>	To make them understand developmental biology in vertebrates, invertebrates and plants

**Expected Course Specific Learning Outcome**

<b>Sr. No.</b>	<b>Learning Outcome</b>
<b>1.</b>	Students understand the concepts and mechanism of anaerobic respiration
<b>2.</b>	Students learn the photosystems and photosynthetic pathways
<b>3.</b>	Students get acquainted with the concepts of developmental biology

**21SMMB124C Microbial respiration, Photosynthesis and developmental Biology****Choice based Optional Theory Paper (Elective)****Total: 2 Credits****Workload: -15 hrs /credit (Total Workload: - 2 credits x 15 hrs = 30 hrs in semester)**

<b>Credit No.</b>	<b>Credit</b>	<b>Workload</b>
<b>I</b>	<b>Respiration and Photosynthesis</b>	<b>15</b>
	Anaerobic Respiration: Concept of anaerobic respiration, oxidized sulfur compounds, and nitrate as electron acceptor with respect to electron transport chain and energy generation, Biochemistry of methanogens. <b>Photosynthesis:</b>	



	1. Organization of photosystem I and II, cyclic and non-cyclic flow of electrons, Z scheme, Hill reaction, photolysis of water 2. C3, C4 CAM plants, Photorespiration, Regulation	
<b>II</b>	<b>Developmental Biology</b>	<b>15</b>
	<p>Introduction to developmental biology</p> <p>Conserved nature of development, Concepts of commitment, determination and differentiation,</p> <p>Morphogen gradients in developmental regulation, Hox code, MPF</p> <p>Gastrulation and cellular movements involved in it, Organizer and its importance giving examples of invertebrates (<i>Drosophila</i>) and vertebrate (<i>Xenopus</i>) model systems, pattern formation in body axis, antero-posterior and dorso-ventral polarity.</p> <p>Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem; shoot and root development; transition to flowering, floral meristems and floral development in <i>Arabidopsis</i>.</p>	



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<b>Course/ Paper Title</b>	<b>Practicals based on Microbial respiration, Photosynthesis and developmental Biology</b>
<b>Course Code</b>	21SMMB126C
<b>Semester</b>	II
<b>No. of Credits</b>	2

**Aims & Objectives of the Course**

<b>Sr. No.</b>	<b>Objectives</b>
<b>1.</b>	To teach the students the methods for isolation of Sulphur reducers and methanogens
<b>2.</b>	To make them learn isolation and characterization of algae and determination of chlorophyll pigment
<b>3.</b>	To demonstrate the stages of embryonic development

**Expected Course Specific Learning Outcome**

<b>Sr. No.</b>	<b>Learning Outcome</b>
<b>1.</b>	Students become capable of isolation of Sulphur reducers and methanogens and characterize them
<b>2.</b>	Students learn to isolate, characterize and determine chlorophyll content in algaeS
<b>3.</b>	Students get aware about the developmental stages of animals and plants

**21SMMB126C:Practicals based on Microbial respiration, Photosynthesis and developmental Biology**

**Choice based Optional Practical Paper (Elective) Total: 2 Credits Workload: -30 hrs**

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

<b>Credit No.</b>	<b>Credit</b>	<b>Workload</b>
<b>I</b>	<b>Respiration and Photosynthesis</b>	<b>30</b>
	1. Enrichment, Isolation and characterisation of Sulphur reducing bacteria/Methanogens. 2. Enrichment, Isolation and characterization of Cyanobacteria.	

	3.Detection of chlorophyll-a activity of Cyanobacteria	
<b>II</b>	<b>Developmental Biology</b>	<b>30</b>
	Demonstration of mounting of embryos (frog and fruit fly) at various developmental stages on permanent slides Observation of stages of development in <i>Arabidopsis</i>	



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<b>Course/ Paper Title</b>	<b>Molecular Biology, Enzymology and Instrumentation Techniques</b>
<b>Course Code</b>	21SMMB125
<b>Semester</b>	II
<b>No. of Credits</b>	4

### **Aims & Objectives of the Course**

<b>Sr. No.</b>	<b>Objectives</b>
<b>1.</b>	To make students aware about enzymology, molecular biology and instrumentation
<b>2.</b>	To make them familiar with various techniques used for biofilm formation, Curing of bacterial Plasmid etc
<b>3.</b>	To teach them applications of molecular techniques, gene annotation

### **Expected Course Specific Learning Outcome**

<b>Sr. No.</b>	<b>Objectives</b>
<b>1.</b>	Students will learn about phylogenetic tree using related sequences and BLAST analysis
<b>2.</b>	Students will learn about Scientific Communication and Research Methodology
<b>3.</b>	Students will be acquainted with EPS, its extraction and estimation

**21SMMB125:Molecular Biology, Enzymology and Instrumentation Techniques**

**Core Compulsory Practical Paper**

**Total: 4 Credits Workload: -30 hrs /credit**

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

1. Concept of lac-operon: Lactose induction of Beta galactosidase; Glucose Repression; Diauxic growth curve of *E. coli*.
2. Crystal violet assay for estimation of biofilm formation
3. Bioassay for determination of quorum sensing signals produced by bacteria.
4. Determination of chemo-taxis responses shown by bacteria using agar plate or capillary tube method.
5. Efflux pump inhibition assay
6. Curing of bacterial Plasmid
7. Gene annotation
8. Sequence matching by BLAST analysis
9. Drawing phylogenetic tree using related sequences (Using standard software like Phylip, Mega etc)
10. Extraction of Protein and Exo-polysaccharide from bacterial culture (TCA and ethanol method)
11. Scientific Communication and Research Methodology  
Concept of effective communication: Presentation skills, formal scientific presentation skills; Preparing power point presentation, Presenting the work, Scientific poster preparation & oral presentation; Participating in group discussions. Technical writing skills: Types, Formats of scientific reports, scientific writing skills, Significance of communicating science, ethical issues, copyrights and plagiarism, Components of a research paper, publishing scientific papers - peer review process and problems. Use of search engines for scientific data mining, use of reference, use of reference management tools (e.g., Zotero).  
(Assignment/activity-based teaching method may be used)
12. Virtual lab exercise to understand the instrumentation, experimentation and interpretation of data obtained using HPLC, FACS, FTIR, GC-MS, NMR, X-Ray crystallography MALDI TOF, SEM, TEM, AFM, Confocal Microscope (representative websites)
13. Visit to any lab or institute to understand the principle and working of the bio-analytical instrument studied in theory courses (optional).