Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar

(Autonomous)

(Affiliated to Savitribai Phule Pune University, Pune)

Choice Based Credit System (CBCS)

Master of Science (M.Sc.)

Syllabus of

M.Sc. Part-I (Microbiology)

Implemented from

Academic year 2021 -22

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar (Autonomous)

Board of studies in Microbiology

Sr. No.	Name	Designation
1.	Mr. Kukreja Girish P.	Chairman
2.	Ms. Giramkar Dipali D.	Member
3.	Dr. Dixit Prashant P.	Academic Council Nominee
4.	Dr. Naphade Bhushan S.	Academic Council Nominee
5.	Mr.Choure Rajendra G.	Vice Chancellor Nominee
6.	Mr. Yewatkar Saikiran	Alumni
7.	Mr. Dube Chandrakant G.	Industry Expert
8.	Dr. Patil Ulhas K.	Member (co-opt)
9.	Mr.Shaikh Sajid H.	Member (co-opt)
10.	Dr. Gahile Yogesh R.	Member (co-opt)
11.	Mr.Wani Ashish S.	Member (co-opt)

1. Prologue/ Introduction of the Programme:

The previous syllabus of M.Sc. Microbiology was sufficient to provide the needs of students to develop their careers in industrial and research sectors. However, with the introduction of Autonomy in the Credit Based Semester and Grading system and also considering the change at the local and global level scenario, we feel that the syllabus orientation should be changed to keep pace with developments in the education and industrial sectors. This syllabus is implemented with effect from 2021-22. The syllabus has been designed such that the theory goes hand in hand with the practicals thus enabling students to develop professional skillsets of a Microbiologist. Theory supplemented with extensive laboratory expertise will help these students, to avail these opportunities. The need to develop research skills and Critical thinking/reasoning in students was also kept in the mind while developing the syllabi. This will aid the students in their specific area of their interest/ specialization in particular. Syllabus covers various topics enlisted for entrance exams i.e. CSIR NET, SET, GATE, PET, ARS, DBT & entrance tests for other Research Institutes. This revised syllabus is aimed at equipping students with theoretical foundations and practical techniques required in R & D, quality control, regulatory function in pharmaceuticals, environmental sciences, Pharmaceutical Microbiology, Advances in Molecular Biology, Applied & Environmental Microbiology and Environmental monitoring and management. Areas covered in Semester I & Semester II will boost employability of students. Thus, college itself will be developing the trained and skilled man-power required in education, industrial and research fields.

2. Programme Outcomes

Students enrolled in the program complete a curriculum that exposes and trains students in a full range of essential skills and abilities. At the time of completion of the programme the students will have developed extensive knowledge in various areas of Microbiology.. By cultivating talents and promoting all round personality development through multi-dimensional education a spirit of self-confidence and self-reliance will be infused in the students. They will have the opportunity to master the following objectives.

- Outline steps in development, differentiation, communication and signaling
- Explore and understand the expanse of the Microbial diversity Identify organisms using bioinformatics tools.
- Explain structure and classification of viruses
- Gain familiarity with applications of microbes for synthesis of valuable products through fermentation.
- Describe, evaluate and use different molecular tools in genetics and modern diagnostic tools.
- Perform procedures as per laboratory standards in the areas of Biochemistry, Bioinformatics, Taxonomy, Ecology, Fermentation and Microbial Technology.
- Use chromatographic and spectroscopic techniques for analysis of biomolecules.
- Assess results of research for accuracy and precision.
- Categorize and communicate ecosystems and explain species interactions.
- Acquire basic Microbiology laboratory skills and expertise in the use of instruments applicable to research, clinical methods and analysis of the observations.
- Understand prokaryotic and eukaryotic genetic systems & physiology of microorganisms.
- Understand the role of microorganisms in human health, immune response to infection and antibiotic resistance.

Programme Structure and Course Titles

Sr. No.	Class	Semester	Course Code	Course Title	Credits
1.	M.Sc.	I	MSC-MR 111 T	Cell Organization and Biochemistry	04
2.	M.Sc.	I	MSC-MR 112 T	Quantitative Biology	04
3.	M.Sc.	I	MSC-MR 113 T	Microbial Systematics	02
4.	M.Sc.	I	MSC-MR 114 P	Practical course based on Biochemical Techniques	02

5.	M.Sc.	I	MSC-MR 115 P	Practical course based on Biostatistics and Bioinformatics	02
6.	M.Sc.	I	MSC-MR 116 P	Practical course based on Developmental Biology and Microbial Diversity	02
7.	M.Sc.	I	MSC-MR 117 T(A)	Fungal Systematics and Extremophiles	02
8.	M.Sc.	I	MSC-MR 117 T(B)	Experimental Design and Quantitative approaches for Biologist	02
9.	M.Sc.	I	MSC-MR 118 P(A)	Practical course based on Fungal Systematics and Extremophiles	02
10.	M.Sc.	I	MSC-MR 118 P(B)	Practical course based on Experimental Design and Quantitative approaches for Biologist	02
11.	M.Sc.	I	MSC-MR 119 T	Evolution and Ecology	02
12.	M.Sc.	II	MSC-MR 211 T	Instrumentation and Molecular Biophysics	04
13.	M.Sc.	II	MSC-MR 212 T	Molecular Biology I	04
14.	M.Sc.	II	MSC-MR 213 T	Nitrogen Metabolism, Respiration and Photosynthesis	02
15.	M.Sc.	II	MSC-MR 214 P	Practical course based on Instrumentation Techniques	02
16.	M.Sc.	II	MSC-MR 215 P	Practical course based on Molecular Biology	02
17.	M.Sc.	II	MSC-MR 216 P	Practical course based on	02

				Nitrogen Metabolism, Respiration and Photosynthesis	
18.	M.Sc.	II	MSC-MR 217 T(A)	The Chemistry and Metabolism of Lipids and Carbohydrates	02
19.	M.Sc.	II	MSC-MR 217 T(B)	Enzymology and Bioenergetics	02
20.	M.Sc.	II	MSC-MR 218 P(A)	Practical course based on Lipid and Carbohydrate Biochemistry	02
21.	M.Sc.	II	MSC-MR 218 P(B)	Practical course based on Enzymology	02
22.	M.Sc.	II	MSC-MR 219 T	Basic Virology	02
23.	M.Sc.	III	MSC-MR 311 T	Immunology	04
24.	M.Sc.	III	MSC-MR 312 T	Molecular Biology II	04
25.	M.Sc.	III	MSC-MR 313 T	Waste Water Treatment	02
26.	M.Sc.	III	MSC-MR 314 P	Practical course based on based on Immunology	02
27.	M.Sc.	III	MSC-MR 315P	Practical course based on Molecular Biology	02
28.	M.Sc.	III	MSC-MR 316 P	Practical course based on Waste Water Treatment	02
29.	M.Sc.	III	MSC-MR 317 T(A)	Cell Culture Techniques	02
30.	M.Sc.	III	MSC-MR 317 T(B)	Bioremediation and Biomass Utilization	02
31.	M.Sc.	III	MSC-MR 318 P(A)	Practical course based on Cell Culture Techniques	02
32.	M.Sc.	III	MSC-MR 318 P(B)	Practical course based on Bioremediation and Biomass Utilization	02
33.	M.Sc.	III	MSC-MR 319 T	Clinical Microbiology	02

34.	M.Sc.	IV	MSC-MR 411 T	Pharmaceutical Microbiology	04
35.	M.Sc.	IV	MSC-MR 412 T	Microbial Technology	04
36.	M.Sc.	IV	MSC-MR 413 T	Research Methodology	02
37.	M.Sc.	IV	MSC-MR 414 P	Practical course based on Pharmaceutical Microbiology	02
38.	M.Sc.	IV	MSC-MR 415 P	Practical course based on Microbial Technology	02
39.	M.Sc.	IV	MSC-MR 416 P	Practical course based on Research Methodology	02
40.	M.Sc.	IV	MSC-MR 417 T(A)	QA validation in Pharma industry and Development of Anti- Infectives	02
41.	M.Sc.	IV	MSC-MR 417 T(B)	Advanced Virology	02
42.	M.Sc.	IV	MSC-MR 418 P(A)	Practical course based on QA validation in Pharma Industry and Development of Anti-Infectives	02
43.	M.Sc.	IV	MSC-MR 418 P(B)	Practical course based on Virology	02
44.	M.Sc.	IV	MSC-MR 419 P	Dissertation	02

AhmednagarJilha Maratha VidyaPrasarakSamaj's

New Arts, Commerce and Science College, Ahmednagar (Autonomous)

Syllabus of M.Sc.I Microbiology

Under

Faculty of Science and Technology

Semester –I	**Paper –I**
Course Code: MSC-MR 111 T	**Title of the Course: Cell Organization and Biochemistry**
Credits: 04	**Total Lectures : 60 Hrs.**

Course Outcomes (Cos)

1. Students will acquire detailed knowledge about structures and features of Proteins.
2. Students will get to know how to apply different techniques of Biochemistry and Molecular Biology in research as well as in different industries.
3. Students will understand Developmental Biology of invertebrates and vertebrate.
4. Students will learn about ultrastructure and organization of Eukaryotic Cell.

Detailed Syllabus

Unit No.	Topics	No. of hours
Unit 1	**Protein Chemistry** 1. Structural features of amino acids, classification of amino acids 2. Amino acids as buffers, Henderson Hasselbalch equation and its role in buffer formulation Peptide linkage, partial double bond nature of peptide bond	15

	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, Non-covalent interactions, Conformational properties of proteins, Polypeptide chain 5. geometry, Resonance forms of the peptide group, cis /trans isomers of peptide group,Ramchandran plot 6. Secondary, Super-secondary, Motif & Domain, Tertiary and Quaternary structures of proteins, (Myoglobin & hemoglobin)	
Unit 2	**Biochemistry and Molecular BiologyTechniques** 1. Chromatography: Principles and applications of gel filtration, Ion exchange, affinity chromatography 2. Electrophoresis: Agarose, Native PAGE, SDS PAGE 3. Polymerase chain reaction: Principle, variations of PCR (Hot start, Nested, Reverse transcription, real time PCR) and its Applications. 4. Sequencing methods: RNA-sequencing methods and applications, DNA sequencing: Classical and next generation sequencing methods (Pyro-sequencing, Ion torrent, Nano-pore sequencing).	15
Unit 3	**Developmental Biology** 1. Introduction to developmental biology. Different model systems used to study developmental biology 2. Conserved nature of development, Concepts of commitment, determination and differentiation, 3. Morphogen gradients in developmental regulation, Hox code, MPF 4. Gastrulation and cellular movements involved in it, Organizer and its importance giving examples of invertebrates (Drosophilla) and vertebrate (Xenopus) model systems, pattern formation in body axis, antero-posterior and dorso-ventral polarity. 5. Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem; shoot and root development; transition to	15

	flowering, floral meristems and floral development in Arabidopsis.	
Unit 4	**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: 3. targeting to secretory vesicles, cell membrane, lysosomes, nucleus, mitochondria and peroxisomes) 4. Events in cell cycle, Regulation of cell cycle. Apoptosis	15

Suggested Readings:

1. Nelson D. L. and Cox M. M., (2002).Lehninger's Principles of Biochemistry, 4thEdition, Mac MillanWorth Pub. Co. New Delhi.
2. Segel I. H., (1997). Biochemical Calculations. 2ndEdition, John Wiley and Sons, NY.
3. Garrett R. H. and Grisham, C. M., (2004). Biochemistry. 3rdEdition, Brooks/Cole, Publishing Company, California.
4. Moat Albert G. and Foster John W., (2002). Microbial Physiology 4thEdition, John Wiley and Sons New York.
5. Berg Jeremy, Tymoczko John, StryerLubert, (2002).*Biochemistry* 5th Edition, W. H. Freeman, New York.
6. Gilbert Scott F., (2010). Developmental Biology. 9th Edition. Sinauer Associates Inc. Mass. USA.
7. Muller W.A., (1997). Developmental Biology, SpringlerVerlag, New York, Inc.
8. Lewis Wolpert, Cheryll Tickle, and Alfonso Martinez Arias, (2015). Principles of Development, 5th Edition, Oxford University press
9. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter., (2002) Molecular Biology of the Cell, 4thEdition, Garland Science; New York

10. Metzler David E., (2001). Biochemistry, 2nd Edition The chemical Reactions of Living Cells, Volume 1&2, Academic Press California.
11. H. Lodish, A. Berk, C. A. Kaiser, M. Krieger, M. P. Scott, A. Bretscher, H. Ploegh, and P. Matsudaira, (2007). Molecular Cell Biology, 6th Edition W. H. Freeman and Company, New York.

Semester –I	**Paper –II**
Course Code: MSC-MR 112 T	**Title of the Course: Quantitative Biology**
Credits: 04	**Total Lectures : 60 Hrs**

Course Outcomes (Cos)

1. Students will understand importance of statistics in biology, measure of center tendency, measure of dispersion, Data presentation, Simple Regression and Correlation.
2. Students will understand the testing of hypothesis - concept of null and alternative hypothesis, t test, Z test, chi square test and nonparametric test.
3. Students will understand the Probability and Probability Distributions.
4. Students will understand accurate and efficient use of specific Statistical tools in the analysis of biological data.

Detailed Syllabus

Unit No.	**Topics**	**No. of hours**
Unit 1	**Descriptive Statistics** 1. Fundamental concepts –Sample Statistics and Population parameter, data (qualitative and quantitative data, discrete and continuous series data), data sources, variables, measurement scales (nominal, ordinal, interval and ratio), variability and uncertainty in measurements 2. Measures of central tendency – Mean Mode, median 3. Measures of dispersion – Mean deviation Standard deviation and Variance 4. Data presentation-Tables and Graphs (Histogram, bar, pie and line) 5. Simple linear Regression and correlation *(significance testing*	15

	not necessary) *(Sr. No. 1:- only theory questions to be asked in exam. Sr. No. 2 – 5:- only problem solving questions to be asked in exam.)*	
Unit 2	**Inferential Statistics-1** 1. Uncertainty: Variation, Probability and inference 2. Central Limit Theorem, Standard deviation of the means standard error and confidence interval 3. The concepts of null hypothesis, Test statistics, P-value significance level, type I and type II errors, one tailed and two tailed tests, degrees of freedom, Parametric and nonparametric test, statistical decision tree, Parametric statistical test: Z-test, t-test and F-test *(Sr. No 1 – 3:- only theory questions to be asked in exam except Z-test, T-test and F-test.)*	15
Unit 3	**Inferential Statistics-2** 1. Test of Significance: Chi square test (Goodness of fit and Independence), 2. Comparison of 3 or more samples – ANOVA One way and two way, Post Hoc test (Tukey's) Nonparametric Tests: comparison to parametric tests, Sign test, Wilcoxon's signed rank test and Mann-Whitney U test	15
Unit 4	**Probability and Probability Distribution** 1. Concept of experiment, event (mutually exclusive & non-exclusive events, dependent & independent events); 2. Laws of probability (addition and multiplication); 3. Probability distribution – Normal (x-scale and z-scale), Binomial and Poisson distributions	15

Suggested Readings:

1. Irfan Ali Khan and Atiya Khanum, Fundamentals of Biostatistics. 3rdEd. Ukaaz, Publications, Hyderabad.
2. Bernard Rosner,(2000).Fundamentals of Biostatistics,5thEdition Duxbury Thomson.
3. Wayne Daniel, (2007). Biostatistics A foundation for Analysis in the health sciences,wileyIn.
4. Norman T. J. Bailey Statistical methods in biology (1995), 3rd Edition, Cambridge University Press.
5. Gupta S.P. Statistical methods, Sultan Chand & Sons Publisher, New Delhi
6. Montgomery D.C. Design and analysis of experiments, 8th Edition John Wiley & Sons
7. Stephen Newman, Biostatistical methods in Epidemiology. Wiley Interscience Publication,
8. Aviva Petrie and Carolene Sabin, (2005), Medical Statistics at a glance, 2nd Edition, Blackwell.
9. David Brown & Peter Rothery. Models in biology: Mathematics, statistics, and computing John Wiley & Sons, USA
10. Brian McNeil and Linda M. Harvey,(2008).Practical Fermentation Technology, John Wiley & Sons, Ltd.
11. Pauline M. Doran, (1995). Bioprocess Engineering Principles by, Elsevier Science & Technology Books.
12. Peter J. Diggle, Amanda G. Chetwynd Statistics and Scientific Method: An Introduction for Students and Researchers, Publisher: Oxford University Press

Semester –I	**Paper –III**
Course Code: MSC-MR 113 T	**Title of the Course: Microbial Systematics**
Credits: 02	**Total Lectures : 30 Hrs.**

Course Outcomes (Cos)

1. Students will develop the capacity to design experiments to assess the total diversity of environmental samples and learn the basics of grouping organisms with respect to their phylogenies
2. Students will understand Concept of speciation and species evolution- types of species and evolution.
3. Students will understand the concept of unculturable bacterial diversity and strategies for culture unculturable bacteria and describe Culture independent molecular methods for identifying unculturable bacteria

Detailed Syllabus

Unit No.	**Topics**	**No. of hours**
Unit 1	**Microbial Systematics & Diversity** 1. Species concept in prokaryotes and eukaryotes 2. Determinative Bacteriology (Phenetic Approach) 3. Systematic Bacteriology (Phylogenetic Approach) 4. Polyphasic Approach 5. Molecular clocks, phylogeny and molecular distances 6. Species divergence and measurement of microbial diversity 7. Measures and indices of diversity; alpha, beta and gamma diversity	15
Unit 2	**Exploration of Un-culturable microbial diversity:**	

	1. Concept of 'unculturable' bacterial diversity 2. Strategies for culture of 'unculturable' bacteria 3. Culture independent molecular methods for identifying unculturable bacteria (PCR, RFLP, ARDRA, DGGE, TGGE, RAPD, Microarray, FISH, RISA) 4. Methods of extracting total bacterial DNA from a habitat and metagenome analysis	15

Suggested Readings:

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. Brown James. Principles of Microbial Diversity.ASM Press, 2014.
3. Catherine Lozupone and Rob Knight, (2008).Species Divergence and the measurement of microbial diversity, FEMS Microbiol. Rev. 32 557 – 578.
4. Jennifer Kirk et al, (2004).Methods of studying soil microbial diversity, Journal of Microbiological Methods 58, 169 – 188.
5. Keller M. and Zengler K., (2004), Tapping in to Microbial Diversity. Nature Reviews 2, 141- 8. Pace N. 6.
6. Breed and Buchanan,(1974). Bergey's Manual of Determinative Bacteriology. 8th Edition
7. Breed and Buchanan,(1982). Bergey's Manual of Determinative Bacteriology. 9th Edition.
8. Breed and Buchanan. (2001-2003)Bergey's Manual of Systematic Bacteriology. 2nd Edition, (Volumes. 1 – 5).
9. Sykes, G. and F. A. Skinner,(1973). Actinomycetales: Characteristics and Practical Importance. Society for Applied Bacteriology Symposium Series No. 2, Academic Press..
10. Jacquelyn G. Black, (2013) Microbiology: Principles and Explorations, 6th Edition, John Wiley & Sons.
11. Lodder J., (1974). The Yeasts: A Taxonomic Study, North Holland Publishing Co. Amsterdam.

12. Michael S. Rappe and Stephen J. Giovannoni, (2003). The Uncultured Microbial Majority. Annual Review of Microbiology, 57: 369 – 94.
13. Rakesh Sharma, Ravi Ranjan, Raj KishorKapardar and Amit Grover, (2005). 'Unculturavble' bacterial diversity: An untapped resource. Current Science, 89 (1)
14. Sonia R. Vartoukian, Richard M. Palmer and William G. Wade, (2010). Strategies for culture of 'un-culturable' bacteria. Minireview, FEMS MicrobiolLett 309, 1 – 7.
15. James D. Oliver, (2005). The Viable but Non-culturable State in Bacteria, The Journal of Microbiology, 43, Special Issue, 93 – 100.
16. Lindell Bromham and David Penny (2003). The Modern Molecular Clock.
17. www.nature.com/reviews/genetics. MARCH 2003 | VOLUME 4, Page. 216. Nature Publishing Group.
18. Leo C. Vining (1992). Roles of secondary metabolites from microbes. Edited by Derek J. Chadwick, Julie. Whelm Copyright.

Semester –I	**Paper –IV**
Course Code: MSC-MR 114 P	**Title of the Course: Practical course based on Biochemical Techniques**
Credits: 02	**Total Lectures : 60 Hrs.**

Course Outcomes (Cos)

1. Students will learn Good Laboratory Practices and their importance.
2. Students will understand preparations of buffers.
3. Students will study methods of extraction of proteins and exopolysaccharide.
4. Students will learn the methods for Biomolecular Separation and Detection.

Detailed Syllabus

Title of the Experiment
• 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.
• Preparation of buffers using KH_2PO_4 and K_2HPO_4, acetic acid and sodium acetate
• Determination of pKa of a monoprotic weak organic acid
• Extraction of Protein /Exo-polysaccharide from bacterial culture(may use TCA and ethanol method)

• Colorimetry and spectrophotometry: Estimation of Protein /Exo-polysaccharide: Bradford and UV Spectrophotometry (purity using A_{280} method).
• Chromatography: Separation of hydrolysed protein /EPS sample using paper and thin layer chromatography.)
• Electrophoresis: SDS-PAGE of proteins
• Interpretation of Ramachandran Plot and study of conformations of protein molecule using Molecular Graphics Visualization Tool (e.g. Swiss PDB)

Semester –I	**Paper –V**
Course Code: MSC-MR 115 P	**Title of the Course: Practical course based on Biostatistics and Bioinformatics**
Credits: 02	**Total Lectures : 60 Hrs.**

Course Outcomes (Cos)

1. Students will be able to sort data using different parameters.
2. Students will be able to represent data in different statistical forms.
3. Students will understand the use of various hypothesis tests to interpret scientific data.

Title of the experiment
• **Computer applications:** (Using Microsoft Excel) • Plotting graphs – bar charts, line graphs, pie charts, adding error bars. (Using data sheets, and sorting data with different parameters)
• Statistical analysis of data using ANOVA, F test(e.g.Using Microsoft Excel)
• Statistical analysis of data using Students t test and Chi square test(e.g.Using Microsoft Excel)
• Referencing in Scientific literature and their practical usage- PubMed
• Pair wise sequence alignment - Local and Global alignment
• Multiple Sequence Alignment – Clustal Omega, Clustal X, T-Coffee, Muscle
• Databases search for homologous sequence using BLAST and FASTA
• Drawing phylogenetic tree using related sequences (Using standard software like Phylip, Mega etc)
• Demonstration of databases (GENBANK, PDB, OMIM) and software (RASMOL, Ligand Explorer)

Semester –I	**Paper –VI**
Course Code: MSC-MR 116 P	**Title of the Course: Practical course based on Developmental Biology and Microbial Diversity**
Credits: 02	**Total Lectures : 60 Hrs.**

Course Outcomes (Cos)

1. Students will understand developmental phases in detail by using model organisms.
2. Students will be able to use Bergey's manual and create keys for the identification of bacteria upto genus level.
3. Students will develop logic of media designing for isolation of a particular group of microorganisms from a particular environment.

Title of the experiment
• Studying the stages of mitosis in growing tip of onion root cells
• Development of in vitro of Fruit fly culture
• Study of various developmental stages of fruit fly and of mounting of embryos
• Isolation and characterization of pigment producing bacteria
• Enrichment, Isolation and identification of the alkalophiles from natural samples
• Demonstration of various stages of chick embryo development
• Isolation and characterization of cellulose degrading bacteria.
• Calculation of Simpson diversity index

Semester –I	**Paper –VII**
Course Code: MSC-MR 117 T(A)	**Title of the Course: Fungal Systematics and Extremophiles**
Credits: 02	**Total Lectures : 30 Hrs.**

Course Outcomes (Cos)

1. Students will understand the classification system of fungi.
2. Students will understand importance of morphological characters in fungal classification.
3. Students will acquire basic knowledge of enrichment and isolation of various extremophile.
4. Students will understand various strategies of adaptions used by extremophiles.

Detailed Syllabus

Unit No.	**Topic**	**No. of hours**
Unit 1	**Fungal Systematics:** 1. Six Classes of Fungi 2. Differentiating characters among different Classes of fungi 3. Importance of morphological characters in fungal differentiation and classification.	15
Unit 2	**Extremophiles** 1.Enrichment, isolation, classification, properties and application of extremophiles:	15

	• Thermophiles, Psychrophiles, Halophiles, Acidophiles, Methanogens 2. Adaptation mechanisms of extremophiles	

Suggested Readings:

1. Barnett, H. L. and Hunter, B. B.,(1960). Illustrated Genera of Imperfect Fungi. Burgess Publishing Co., Minnesota.
2. Lodder J., (1974). The Yeasts: A Taxonomic Study, North Holland Publishing Co. Amsterdam.
3. Rampelotto PH. (2013). Extremophiles and extreme environments. *Life (Basel)*.3(3):482-485. Published 2013 Aug 7. doi:10.3390/life3030482.
4. Gómez, F., (2011). *Extreme Environment. Encyclopedia of Astrobiology, 570–572*.doi:10.1007/978-3-642-11274-4_566.
5. D'Amico S, Collins T, Marx JC, Feller G, Gerday C. (2006) Psychrophilic microorganisms: challenges for life. *EMBO Rep*. ,7(4):385-389. doi:10.1038/sj.embor.7400662.
6. De Maayer P, Anderson D, Cary C, Cowan DA.,(2014). Some like it cold: understanding the survival strategies of psychrophiles. *EMBO Rep*.;15 (5):508-517. doi:10.1002/embr.201338170.
7. Sterner, R. hard, & Liebl, W., (2001). *Thermophilic Adaptation of Proteins. Critical Reviews in Biochemistry and Molecular Biology, 36(1), 39–106*.doi:10.1080/20014091074174.
8. Coker JA.,(2016).Extremophiles and biotechnology: current uses and prospects. *F1000Res*.;5: F1000 Faculty Rev-396. Published Mar 24. doi:10.12688/f1000research.7432.1
9. Johnson DB, Schippers A., (1992) Editorial: Recent Advances in Acidophile Microbiology: Fundamentals and Applications. *Front Microbiol*. 2017;8:428. doi:10.3389/fmicb.2017.00428

10. Mirete, S., Morgante, V., & González-Pastor, J. E., (2017). *Acidophiles: Diversity and Mechanisms of Adaptation to Acidic Environments. Adaption of Microbial Life to Environmental Extremes, 227–251.*doi:10.1007/978-3-319-48327-6_9
11. Mamo, G., &Mattiasson, B., (2020). *Alkaliphiles: The Versatile Tools in Biotechnology. Advances in Biochemical Engineering/Biotechnology*.doi:10.1007/10_2020_126
12. Lebre, Pedro & De Maayer, Pieter & Cowan, Donald. (2017). Xerotolerant bacteria: Surviving through a dry spell. Nature Reviews Microbiology. 15. 10.1038/nrmicro.2017.16.
13. Grant WD. (2004), Life at low water activity. *Philos Trans R SocLond B Biol Sci*.;359(1448):1249-1267. doi:10.1098/rstb.2004.1502
14. Edbeib, M. F., Wahab, R. A., &Huyop, F., (2016). *Halophiles: biology, adaptation, and their role in decontamination of hypersaline environments. World Journal of Microbiology and Biotechnology, 32(8).*doi:10.1007/s11274-016-2081-9.
15. Coker JA. , (2019). Recent advances in understanding extremophiles. *F1000Res*.;8: F1000 Faculty Rev-1917. Published 2019 Nov 13. doi:10.12688/f1000research.20765.1.

Semester –I	**Paper –VII**
Course Code: MSC-MR 117 T(B)	**Title of the Course: Experimental Design and Quantitative approaches for Biologist**
Credits: 02	**Total Lectures : 30 Hrs.**

Course Outcomes (Cos)

1. Students will understand the basic concept of scientific research.
2. Students will develop capacity to find research problems, selection of appropriate research design and implementation of research project.
3. Students will acquire knowledge of various approaches of data collection, analysis and presentation.

Detailed Syllabus

Unit No.	**Topics**	**No. of hours**
Unit 1	**Designing of Experiments** 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 PlackettBurman) 5. Epidemiological Study designs: Case control, cohort, concurrent, cross-sectional, retrospective/prospective 6. Clinical/field trials-Randomization, Bias removal (Blinding	15

	– single & double), controlled and uncontrolled trials	
Unit 2	**Mathematical approach for Biologists** *(Basic rules and application of limits, derivative and integration need to be discussed)* 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	15

Suggested Readings:

1. Gerry P. Quinn , Michael J. Keough, (2002).Experimental Design and Data Analysis for Biologists, ,Cambridge University Press.
2. Graeme D. Ruxton ,NickColegrave , (2006). Experimental Design for the Life Sciences, 2nd Edition .(2006) OUP Oxford.
3. Stanley E. Lazic, (2016). Experimental Design for Laboratory Biologists: Maximising Information and Improving Reproducibility ,Cambridge University Press; 1st edition

Semester –I	**Paper –VIII**
Course Code: MSC-MR 118 P(A)	**Title of the Course: Practical course based on Fungal Systematics and Extremophiles**
Credits: 02	**Total Lectures : 60 Hrs.**

Course Outcomes (Cos)

1. Students will be able to isolate yeast and molds form natural sample using different methods and their identification technique.
2. Students will develop Logical development of sample selection, media designing for isolation of extremophilicbacteria.
3. Student will be able to make use of Bergey's Manuals to prepare keys for identification of extremophiles up to genus level.

Title of the experiment
• Isolation and characterization of yeasts from natural samples.
• Isolation and characterization of saprophytic molds from natural samples
• Isolation and identification of the Acidophiles from natural samples
• Isolation and identification of the Halophiles from natural samples
• Isolation and identification of the anaerobic bacteria from natural samples
• Isolation and identification of the Thermophiles from natural samples

Semester –I	**Paper –VIII**
Course Code: MSC-MR 118 P(B)	**Title of the Course : Practical course based on Experimental Design and Quantitative approaches for Biologist**
Credits: 02	**Total Lectures : 60 Hrs.**

Course Outcomes (Cos)

1. Student will gain the ability to develop research proposals.
2. Student will be able to evaluate and select appropriate data analytical tool and software solutions.
3. Student will be able to draw appropriate conclusions form experimental research.
4. Student will be able to perform statistical survey.

Detailed Syllabus

Title of the experiment
• Designing of Mock Research Proposal which includes: 1. Title 2. Hypothesis 3. Review of Literature 4. Methodology *(Specify Statistical Methods)* 5. Possible outcomes *(Statistical Interpretations)* 6. References • *Scientific writing should be followed for Research proposal*
• Epidemiological study Proposal *(Mini Project)* 1. Identification of Problem and Establishing Hypothesis 2. Selection of Design 3. Data Collection 4. Data Analysis

5. Data Presentation 6. Conclusion • *Scientific writing should be followed for proposal*
• Statistical Survey 1. Identification of Problem and Establishing Hypothesis 2. Survey Design (Questionnaire based) 3. Preparation of Questionnaire 4. Data Collection 5. Data Analysis 6. Data Presentation 7. Conclusion of Survey
• Factorial Study Design for Optimization of Media conditions -(Placket barmen design) 1. Data collection from Research Papers/ Dissertations /Journals 2. Data Treatment using Statistical Software's (Mini tab, SPSS and Design Expert)
• Factorial Study Design for Optimization of Media conditions -(Fractional Factorial) 1. Data collection from Research Papers/ Dissertations /Journals 2. Data Treatment using Statistical Software's (Mini tab, SPSS and Design Expert)
• Factorial Study Design for Optimization of Media conditions -(Full Factorial) 1. Data collection from Research Papers/ Dissertations /Journals 2. Data Treatment using Statistical Software's (Mini tab, SPSS and Design Expert)
• 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
• 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- R programming)*
• Statistical analysis of data – Students t test, ANOVA using computer software*(Using Statistical Packages other than Microsoft Excel-R programming*)
• Statistical analysis of data –Chi square test, F test using computer software*(Using Statistical Packages other than Microsoft Excel- R programming*)

Semester –I	**Paper –IX**
Course Code: MSC-MR 119 T	**Title of the Course: Evolution and Ecology**
Credits: 02	**Total Lectures : 30 Hrs.**

Course Outcomes (Cos)

1. Student will understand various evolutionary theories and difference among them.
2. Student will understand key concept of evolutionary biology, the history of life on earth and the phylogenetic relationship between organisms.
3. Student will understand the ecological relationship between organisms and their environment and dynamic nature of ecosystem.

Detailed Syllabus

Unit No.	**Topics**	**No. of hours**
Unit 1	**Evolution** 1.History and development of evolutionary theory (Lamarckism, Darwinism), Neo Darwinism: Spontaneous mutation controversy, evolution of rates of mutation, types of selection, levels of selection, group selection and selfish gene. 2.Socio-biology, kin selection, evolutionary stability of cooperation, sociality and multicellularity in microorganisms, Game theory. Co-evolutionary strategies, host parasite coevolution 3.Molecular evolution: origin of life, the origin of new genes and proteins. ageing, evolutionary trade-offs, r and k selection	15
Unit 2	**Ecology** 1.The Environment: Physical environment; biotic environment;	

	biotic and abiotic interactions. 2.Community ecology: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis. 3.Concept of habitat and niche; Niche width and overlap; fundamental and realized niche; resource partitioning; character displacement. Speciation: Allopatric, peripatric, parapatric, and sympatric. 4. Ecological succession: Types and mechanisms of succession and concept of climax 5. Ecosystem Ecology:Ecosystem structure, Ecological pyramids, Energy flow and food chain length.	15

Suggested Readings:

1. Ridley Mark, (2004). Evolution, Blackwell Science Ltd.
2. Woese C., (1987), Bacterial Evolution. Microbiological Reviews, 221-271.
3. Lively Curtis, M. (1996). Host-parasite coevolution and sex. Bioscience 46, 2, 107.
4. Anders Gorm Pedersen, (2005). Molecular Evolution: Lecture Notes.
5. Dash, M.C., (1993). Fundamentals of Ecology. Tata McGraw Hill Publishing Hill Co. Ltd., New Delhi.
6. Richards, B. N., (1987). Microbiology of Terrestrial Ecosystems, Longman. Scientific and Technical, N.Y.
7. Madigan et al., (2011). Brock Biology of Microorganisms, 13thEdition. Pearson.

Semester –II	**Paper –I**
Course Code: MSC-MR 211 T	**Title of the Course: Instrumentation and Molecular Biophysics**
Credits: 04	**Total Lectures : 60 Hrs.**

Course Outcomes (Cos)

1. Student will learn Biomolecular Separation and Detection methods.
2. Student will understand Biophysical Techniques.
3. Student will learn application of radioisotopes in biology.
4. Student will learn the principles and working of SEM , TEM and confocal microscopy.

Detailed Syllabus

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

Unit 2	**Spectroscopy** 1. Introduction: Electromagnetic spectrum, Atomic orbitals, Molecular orbitals, Electronic, Rotational and Vibrational transitions in spectroscopy, Interpretation of spectra. 2. UV/Visible spectroscopy- Instrumentation, Molar Absorptivities, Beer and Lamberts Law, Bathochromic and hypochromic shifts. 3. Fluorescence spectroscopy- Instrumentation, Quantum Yield, Quenching, FRET, Binding and Folding studies, Flow cytometry and FACS 4. Infrared spectroscopy- Principle, Instrumentation, Absorption bands, FTIR and its applications 5. Mass spectroscopy- Principles of operation, Ionization, Ion fragmentation, Mass Analysers, GC-MS, MALDI-TOF	15
Unit 3	**Biophysical Techniques** 1. NMR spectroscopy: Basic Principles of NMR, Chemical shift, Spin -Spin coupling, Nuclear Overhauser Effect, NMR Applications in Biology 2. X-ray crystallography: purification of proteins, crystallization of proteins, instrumentation, acquisition of the diffraction pattern, basic principles of x-ray diffraction, Phase determination	10
Unit 4	**Radioisotopes in Biology and Microscopy** **1. Radioisotopes in Biology:** • Principles and applications of radio tracers in medicine, agriculture, industry, and fundamental research • Radiation and Radioactive isotopes: Types, Quantities and units of estimation, half-life of isotopes • Detection and measurement of radioactivity- Autoradiography,	20

	Liquid scintillation counting. • Effect of radiation on biological system **2. Principle, working and application of:** • Confocal Microscopy • Transmission Electron Microscopy • Scanning Electron Microscopy	

Suggested Readings :

1. Clive Dennison, (2002).A guide to protein isolation, Kluwer Academic Publishers.
2. Pattabhi, V. and Gautham, N., (2002).Biophysics. Kluwer Academic Publishers, New York and Narosa Publishing House, Delhi.
3. David J Holme, Hazel Peck, (1998). Analytical Biochemistry, 3rd Edition Prentice Hall, Pearson Education Limited, Harlow England.
4. Rodney F. Boyer, (2000), Modern Experimental Biochemistry 3rdEdition., Benjamin Cummings.
5. Nölting, B., (2006).Methods in modern biophysics.2ndEdition. Springer, Germany.
6. Wilson Keith and Walker John,(2005). Principles and Techniques of Biochemistry and Molecular Biology, 6th Ed.Cambridge University Press, New York.
7. Rolf Ekman, Jerzy Silberring, Ann Westman-Brinkmalm, AgnieszkaKraj, (2009). Mass spectrometry: instrumentation, interpretation, and applications, John Wiley & Sons,Inc.,Canada.
8. Irwin H. Segel, (1976). Biochemical Calculations: How to SolveMathematical Problems in General Biochemistry, 2nd Edition.John Wiley & Sons.
9. Mount, D. W., (2001). Bioinformatics: sequence and genomeanalysis. Cold Spring Harbor Laboratory Press, New York.
10. David M Webster, (2000). Protein Structure Prediction-Methods and Protocols, Methods In Molecular Biology Vol143 Humana Press.

11. Narayanan, P., (2000). Essentials of Biophysics. New Age International Publication, New Delhi.
12. Christof M. Niemeyer and Chad A. Mirkin, (2006).Nanobiotechnology, John Wiley & Sons.
13. Daniel L. Feldheim and Colby A. Foss, Jr., (2002). Metal nanoparticles synthesis and characterization and applications Marcel Dekker, Inc.
14. MahendraRai and Nelson Duran, (2011). Metal nanoparticles in Microbiology, Springer Verlag Berlin Heidelberg.
15. Sohier, J., Laurent, C., Chevigné, A., Pardon, E., Srinivasan, V., Wernery, U. Galleni, M., (2013). Allosteric Inhibition of VIM Metallo-β-Lactamases by a CamelidNanobody.Biochemical Journal, 450(3), 477-486. doi:10.1042/bj20121305.
16. Chakravarty, R., Goel, S., &Cai, W., (2014). Nanobody: The "Magic Bullet" for Molecular Imaging? Theranostics, 4(4), 386-398. doi:10.7150/thno.8006.

Semester –II	**Paper –II**
Course Code: MSC-MR 212 T	**Title of the Course: Molecular Biology I**
Credits: 04	**Total Lectures : 60 Hrs.**

Course Outcomes (Cos)

1. Students will learn different Tools used inmolecular biology, genetic engineering and Molecular Diagnostics.
2. Students will learn the Mechanism of RNA processing like splicing and nuclear export.
3. Students will understand the concept of various genome projects.

Detailed Syllabus

Unit No.	**Topics**	**No. of hours**
Unit 1	**RNA processing & Molecular Techniques** 1. RNA Processing: Eukaryotic • mRNA splicing (Spliceosome and auto splicing by Intron I and Intron II), rRNA processing, tRNA processing, RNA Editing, • Nuclear export of mRNA • Regulatory RNAs and noncoding RNAs : Si RNA, Micro RNA, RNAi • Pi RNA (PIWI interacting RNAs) 2. Molecular Techniques Knockout mice, phage display, expressed sequence tags, Yeast two and three hybrid assay, Activity gel assay, DNA helicase assay, Chromatin Immuno-precipitation (ChIP),	15

	Designing probe, Epitope tagging	
Unit 2	**Tools for Genetic engineering** 1. Restriction endonucleases and methylases; DNA ligase, klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labeling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and farwestern and colony hybridization, fluorescence *in situ* hybridization. 2. Vectors for cloning and gene expression: Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Blue script vectors, *Baculovirus* and *Pichia*vectors, plant-based vectors (Ti and Ri as vectors). Vectors for gene expression: types (pMal, GST, pET-based vectors), Protein purification (His-tag, GST-tag, MBP-tag) 3. Construction of cDNA and genomic libraries	15
Unit 3	**Genome projects** 1. Concept and meaning of genome projects and their applications 2. Introduction to Genome projects of *E. coli*, yeast, Plasmodium,Fruit fly, Mouse, Drosophila, and Rice and comparative genomics 3. Gene annotation 4. Human Genome project and its applications	15
Unit 4	**Molecular diagnostics and applications** 1. Protein arrays to detect polygenic diseases, Immunoassay for protein confirmation-specific disorders 2. Detection of diseases-associated changes in gene expression using microarray 3. Detection of RNA signatures of Antibiotic Resistance in Bacteria 4. Detection of miRNA signatures of Cancer	15

Suggested References:

1. Benjamin Lewin, (2008). Genes IX, Jones and Bartelett Publishers Inc.
2. S.B Primrose and R M Twyman, (2006). 7th Edition. Blackwell publishing .
3. James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Loswick, (2004). Molecular Biology of the Gene, 5th Edition, Pearson Education, Inc.
4. Bruce Albert et. al., Molecular Biology of the Cell, 6th Edition, Garland Sciences.
5. W. H. Freeman, Loddishet. al., (2012). Molecular Biology, 7th Edition.
6. Weaver R., (2007) Molecular Biology, 4th Edition, McGrew Hill Science.
7. B. R. Glick, J.J. Pasterneck, Principles and applications of recombinant DNA, 3rd Edition, ASM press.

Semester –II	**Paper –III**
Course Code: MSC-MR 213 T	**Title of the Course: Nitrogen Metabolism, Respiration and Photosynthesis**
Credits: 02	**Total Lectures : 30 Hrs.**

Course outcomes (Cos)

1. Students will understand process of biological nitrogen fixation at molecular level.
2. Students will acquire detailed information of anaerobic respiration.
3. Students will gain the knowledge of photosynthesis at molecular level.

Detailed Syllabus

Unit No.	**Topics**	**No. of hours**
Unit 1	**Nitrogen Metabolism** 1. Biochemistry of biological nitrogen fixation, properties of nitrogenase and its regulation 2. Ammonia assimilation, glutamine synthetase, glutamate dehydrogenase, glutamate synthetase, their properties and regulation, 3. Biosynthesis of five families of amino acids and histidine, 4. Biosynthesis of purine and pyrimidine bases	15
Unit 2	**Anaerobic Respiration and Photosynthesis** **Anaerobic Respiration:** 1. 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 methanogenes.	15

	Photosynthesis: 1. Organization of photosystem I and II, cyclic and non-cyclic flow of electrons, Z scheme, Hill reaction, photolysis of water C3, C4 CAM plants, Photorespiration, Regulation of photosynthesis	

Suggested Readings:

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 Edition, John Wiley and Sons, NY.
3. Garrett, R. H. and Grisham, C. M., (2004). Biochemistry. 3rd Edition, Brooks/Cole, Publishing Company, California.
4. Moat Albert G. and Foster John W., (2002). Microbial Physiology 4thEdition, John Wiley and Sons New York.
5. Berg Jeremy, Tymoczko John, StryerLubert, (2002). Biochemistry 5th Edition, W. H. Freeman, New York.
6. Michael T. Madigan, John M. Martinko, David A. Stahl, David P. Clark, (2012). Brock Biology of Microorganisms, 13th Edition, Benjamin Cummings, San Francisco.
7. White David, (2000). Physiology and Biochemistry of Prokaryotes. 2nd Edition Oxford University Press, New York.
8. Mandelstam Joel and McQuillen Kenneth, (1976). Biochemistry of Bacterial Growth, Blackwell Scientific Publication London.

Semester –II	**Paper –IV**
Course Code: MSC-MR 214 P	**Title of the Course: Practical course based on Instrumentation techniques**
Credits: 02	**Total Lectures : 60 Hrs.**

Course outcomes (Cos)

1. Students will be able to determine molar extinction coefficient of biomolecule
2. Students will how to perform column chromatography.
3. Students will learn the biosynthesis of nanoparticles and their characterization.
4. Students will understand the principle ,working and calibration of the bio-analytical instruments.

Title of the experiment
• Determination of molar extinction coefficient of biomolecule
• Calibration of analytical instruments – Colorimeter and Spectrophotometer by estimation of biomolecules and statistical analysis of data generated.
• Separation of amino acids by thin layer and paper chromatography
• Separation of sugar by thin layer and paper chromatography
• Determination of Nature and Capacity of ion exchange resins
• Column chromatography – Separation of a mixture of proteins and salt using Sephadex column
• Biological synthesis of nanoparticles using actinomycetes /fungi/yeast and their characterization by UV-Vis spectroscopy
• FTIR analysis of biomolecules
• 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)
• Visit to any lab or institute to understand the principle and working of the bio-analytical instrument studied in theory courses

Semester –II	**Paper –V**
Course Code: MSC-MR 215 P	**Title of the Course: Practical course based on Molecular Biology**
Credits: 02	**Total Lectures : 60 Hrs.**

Course Outcomes (Cos)

1. Students will understand working of lac operon.
2. Students will be able to perform gene annotation.
3. Students will understand plasmid isolation , quantification and curing of bacterial plasmid.

Title of the experiment
• Isolation of Plasmid DNA from a bacterial sample
• Quantitation and characterization of plasmid DNA by gel electrophoresis
• Construction of restriction digestion map of plasmid DNA
• Curing of bacterial Plasmid
• Gene annotation
• Diauxic growth curve of *E. coli.*
• Isolation of chromosomal DNA of bacteria, purity checking using A260/A280 ratio
• Agarose gel electrophoresis of isolated chromosomal DNA of bacteria
• Demonstration of thePCR technique

Semester –II	**Paper –VI**
Course Code: MSC-MR 216 P	**Title of the Course: Practical course based on Nitrogen Metabolism, Respiration and Photosynthesis**
Credits: 02	**Total Lectures : 60 Hrs.**

Course outcomes (Cos)

1. Students will acquire practical knowledge of isolation of plant growth promoting bacteria form different samples.
2. Students will be able to handle extraction techniques.
3. Students will be able to isolate and characterize photosynthetic bacteria, Sulphur reducing bacteria, lignin and xylan degrading microorganisms.

Title of the experiment
• Isolation of IAA producing microorganism
• Isolation of siderophore producing microorganism
• Enrichment ,Isolation and characterization of nitrogen fixing bacteria
• Enrichment, Isolation and characterization of Sulphur reducing bacteria/Methanogens.
• Enrichment, Isolation and characterization of Cyanobacteria.
• Enrichment, Isolation and characterization of ammonia producing bacteria

Semester –II	**Paper - VII**
Course Code: MSC-MR 217 T(A)	**Title of the Course: The Chemistry and Metabolism of Lipids and Carbohydrates**
Credits: 02	**Total Lectures : 30 Hrs.**

Course outcomes (Cos)

1. Students will understand Carbohydrate and lipid classification and biochemistry.
2. Students will learn the carbohydrate synthesis by various pathways and understand its metabolism
3. Students will understand the synthesis and degradation of various lipids.

Detailed Syllabus

Unit No.	**Topics**	**No.of hours**
Unit 1	**Lipid Chemistry and Metabolism** 1. Classification of lipids according to chemical structure, 2. Fatty acids, saturated, unsaturated, branched, nomenclature system, 3. Structure and function of: triglycerides, phospholipids, sphingolipids, terpenes, prostaglandins, waxes, and steroids. 4. Synthesis of storage lipids: Fatty acids and triacylglycerols, 5. Synthesis of membrane lipids: Glycerophospholipids, sphingolipids, sterols, 6. Degradation of fatty acids (beta oxidation and unsaturated fatty acid) and fats in animals *7.* Lipids as signal molecules (eg. phosphatidyl inositol, eicosanoids*).*	15
Unit 2	**Carbohydrate Chemistry and Metabolism** 1. Mono, di, oligosaccharides and polysaccharides, with examples 2. Isomerism in sugars: asymmetric centres in sugars, dextro, leavo-	

	rotatory, sugar anomers (reducing and non-reducing sugars), sugar epimers 3. Sugar derivatives such as sugar alcohols, amino sugars, sugar acids, deoxy sugars 4. Glycolysis and gluconeogenesis, Regulation of glycolysis and gluconeogenesis, 5. Synthesis of microbial exopolysaccharides 6. Cellulose synthesis and breakdown 7. Regulation of Glycogen synthesis; breakdown, 8. Metabolic flux and its regulation by various metabolic intermediates, 9. TCA cycle- regulation, role in energy generation, Role in generating biosynthetic intermediates and glyoxylate cycle	15

Suggested Readings:

1. Nelson D. L. and Cox M. M., (2005). Lehninger's Principles of Biochemistry, 4th Edition, W.H. Freeman & Co. New York.
2. Palmer Trevor, (2001). Enzymes: Biochemistry, Biotechnology and Clinical chemistry, Horwood Pub. Co. Chinchester, England.
3. Segel Irvin H., (1997). Biochemical Calculations 2nd Edition, John Wiley and Sons, New York.
4. Garrett, R. H. and Grisham, C. M., (2004). Biochemistry. 3rd Edition, Brooks/Cole, Publishing. Company, California
5. Michael T. Madigan, John M. Martinko, David A. Stahl, David P. Clark, (2012). Brock Biology of Microorganisms, 13th Edition, Benjamin Cummings, San Francisco.
6. Moat Albert G. and Foster John W., (1988). Microbial Physiology 2nd Edtion, John Wiley
7. Berg Jeremy, Tymoczko John, StryerLubert, (2001). Biochemistry 4th Edition, W. H. Freeman, NY.
8. White David, (2000). Physiology and Biochemistry of Prokaryotes. 2nd Editoin, Oxford University Press, New York. 2. Mandelstam Joel and McQuillen Kenneth (1976) Biochemistry of Bacterial Growth, Blackwell Scientific Publication London.

Semester –II	**Paper –VII**
Course Code: MSC-MR 217 T(B)	**Title of the Course: Enzymology and Bioenergetics**
Credits: 02	**Total Lectures : 30 Hrs.**

Course outcomes (Cos)

1. Student will gain detailed information of enzyme structure, purification, kinetics, inhibitors etc.
2. Students will learn the concept of allosterism, models and kinetics of allosteric enzymes .
3. Students will learn the significance of allosteric enzymes in regulation.
4. Student will understand the laws of thermodynamics, Gibbs free energy equation.
5. Student will learn to determine free energy of biological oxidation reduction reactions.
6. Student will learn about high energy compounds, Atkinson's energy charge etc.

Detailed Syllabus

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

	examples of allosteric enzymes and their significance in regulation.	
Unit 2	**Bioenergetics** 1. Laws of thermodynamics, entropy, enthalpy, free energy, free energy and equilibrium constant Gibbs free energy equation with reference to biological significance. 2. Determination of free energy of hydrolytic and biological oxidation reduction reactions under standard and non-standard conditions 3. High energy compounds 4. Coupled reactions 5. Determination of feasibility of reactions 6. Problems based on 2 and 4. 7. Atkinson's energy charge.	15

Suggest Readings :

1. Nelson D. L. and Cox M. M., (2005). Lehninger's Principles of Biochemistry, 4th Edition, W.H. Freeman & Co. New York.
2. Palmer Trevor, (2001). Enzymes: Biochemistry, Biotechnology and Clinical chemistry, Horwood Pub. Co. Chinchester, England.
3. Segel Irvin H., (1997). Biochemical Calculations 2nd Edtion., John Wiley and Sons, New York.
4. Garrett, R. H. and Grisham, C. M., (2004). Biochemistry. 3rd Edifion, Brooks/Cole, Publishing Company, California
5. Michael T. Madigan, John M. Martinko, David A. Stahl, David P. Clark, (2012). Brock Biology of Microorganisms, 13th Edition, Benjamin Cummings, San Francisco.
6. Moat Albert G. and Foster John W., (1988). Microbial Physiology 2nd Edition. John Wiley.
7. Berg Jeremy, Tymoczko John, StryerLubert, (2001). Biochemistry 4th Ed, W. H. Freeman, NY.

8. White David, (2000). Physiology and Biochemistry of Prokaryotes. 2nd Ed. Oxford University Press, New York. 2. Mandelstam Joel and McQuillen Kenneth (1976) Biochemistry of Bacterial Growth, Blackwell Scientific Publication London.

Semester –II	**Paper -VIII**
Course Code: **MSC-MR 218 P(A)**	**Title of the Course: Practical course based on Lipid and Carbohydrate Biochemistry**
Credits: 02	**Total Lectures : 60 Hrs.**

Course outcomes (Cos)

1. Students will be able to analyse the antimicrobial properties of plant actives.
2. Students will characterize and quantify the lipids and carbohydrates.
3. Students will be able to detect and analyze the lipid and carbohydrate based plant or microbial origin sample.

Title of the experiment
• Determination of total soluble sugars by ferricyanide method.
• Production of microbial exopolysaccharide and its detection
• Enrichment and isolation of lignin/xylan degraders from Soil
• Determination of acid value of fatty acid
• Determination of Saponification value of fatty acid
• Determination of Iodine number of fatty acid
• Analysis of microbial degradation of lipid (rancidity)
• Isolation of Biosurfactant producing bacteria
• Extraction and determination of Antimicrobial activity of plant oils
• Extraction and estimation of total lipid content in the given sample of oil seed

Semester –II	**Paper -VIII**
Course Code: MSC-MR 218 P(B)	**Title of the Course**: **Practical course based on Enzymology**
Credits: 02	**Total Lectures : 60 Hrs.**

Course outcomes (Cos)

1. Students will be able to purify enzymes using different methods.
2. Students will be able analyze kinetic properties of enzymes.
3. Students will be able to isolate enzyme producing microbes

Title of the Experiment
• Isolation of enzyme Producing microorganism , production and quantification of the Enzyme produced : (any two) • Protease/Lipase/ Chitinase/ Cellulase
• Purification of enzymes (Amylase/Invertase): (any one method - ammonium sulphate precipitation, organic solvent precipitation, gel filtration, etc.) and Establishment of enzyme purification chart
• Effect of temperature/pH/Salt/activators/ inhibitors/ on Enzyme activity (any one factor or parameter on any one enzyme)
• Determination of Km and Vmax values of enzyme (any two enzymes)

Semester –II	**Paper -IX**
Course Code: MSC-MR 219 T	**Title of the Course: Basic Virology**
Credits: 02	**Total Lectures : 30 Hrs.**

Course Outcomes (Cos)

1. Student will learn the basic structure of viruses.
2. Student will understand the structure and replication of viruses.
3. Student will acquire knowledge about nomenclature& Classification systems of viruses.
4. Student will learn methods for cultivation of viruses.

Detailed Syllabus

Topic No.	**Topic**	**No. of hours**
Unit 1.	**1. Introduction to Virology**: Animal viruses, plant viruses, bacteriophages • **Structure of Viruses** • Enveloped and Non enveloped viruses • Capsid symmetries – Icosahedral, Polyhedral and Helical • Structural components of virus – • Protein - Envelope proteins, Matrix proteins and Lipoproteins • Genome – dsDNA, ssDNA, dsRNA, ssRNA (positive sense, negative sense and ambisense), linear, circular, segmented • Virus related structures – Viroids and Prions	07
	2.Replicationofviruses • Virus infection and replication in a host cell: recognition of the host cell, strategies of genomic replication and gene expression in	08

	DNA and RNA viruses, control of viral replication, virus assembly, release from the host cell and maturation • (with representative life cycle of)	
Unit 2	**1. Cultivation of viruses:** • *In ovo*: using embryonated chicken eggs • *In vivo*: using experimental animals • *Ex vivo / In vitro:* using various cell cultures - primary and secondary cell lines, suspension cell cultures and monolayer cell culture	07
	2.Diagnostic and detection methods for viruses: • Direct methods of detection – Light microscopy (inclusionbodies), Electron microscopy and Fluorescence microscopy • Immnuodiagnosis, Hemagglutination and Hemagglutinationinhibitiontests, Complement fixation, Neutralization,Western blot, Radioactive Immuno Precipitation Assay(RIPA) • Nucleic acid based diagnosis: Nucleic acid hybridization, Polymerase Chain Reaction (PCR) • Infectivity assay for animal and bacterial viruses – Plaquemethod, Pock counting, End point methods, LD50, ID50,EID50, TCID50	08

Suggested Readings:

1. Cann A.J, (2005). Principles of Molecular Virology, 4th Editon, Elsevier Academic Press.
2. Dimmock N. J., Easton A. J. and K. N. Leppard, (2007), Introduction to Modern Virology, 6th Edtion, Blackwell Publishing.
3. Edward K. Wagner, Martinez J. Hewlett, (2004). Basic Virology, Blackwell Publishing.

4. Flint S. J., V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka, (2003). Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses, American Society Microbiology.
5. Haaheim L. R., J. R. Pattison and R. J. Whitley, (2002). A Practical Guide to Clinical Virology. 2nd Edtion, Edited by, John Wiley & Sons, Ltd.
6. Knipe David M., Peter M. Howley, Diane E. Griffin, Robert A. Lamb, Malcolm A. Martin, Bernard Roizman, Stephen E. Straus, (2007). Field's Virology, 5th Edition, Lippincott Williams & Wilkins
7. Luria S. E. et.al., (1978), General virology, 3rd Edition, New York.John Wiley and Sons.
8. Straus J. H. and Straus E.S., (1998). Evolution of RNA Viruses Ann. Rev. Microbiol. 42: 657 – 83.
9. Baltimore D., (1971). Expression of Animal Virus Genomes,Microbiology and molecular Bioology Reviews, 35(3), 235 –241.
10. Cornelia Buchon-Osmond, (2003). The Universal Virus Database ICTV db Computing in science and Engineering,May/June, pp 2-11.
11. Fenner F, (1976). The Classification and Nomenclature of Viruses Summary of Results of Meetings of the International Committee on Taxonomy of Viruses in Madrid, September 1975, Journal of General Virology, 31, 463-470.
12. http://ictvonline.org/codeOfVirusClassification_2012.asp
13. Mahy B. WJ. And Kangro H.O., (1996). Virology Methods Manual, Academic Press.
14. Shors T. (2011). Understanding Viruses, 2nd Ed., Jones & Bartlett Publishers LLC, Canada.