Savitribai Phule Pune University

(Formerly University of Pune)

Two Year Degree Program in Microbiology

(Faculty of Science & Technology)

Revised Syllabi for

M.Sc. (Microbiology) Part-I

(For Colleges Affiliated to Savitribai Phule Pune University)

Choice Based Credit System Syllabus

To be implemented from Academic Year 2019-2020

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, behavioural and evolutionary aspects

- **Microbial diversity in extreme environments**: Properties and application of extremophilesand also includes collecting information of diversity, exploration and utilization of diversity to identify and harvest biomolecules for human health improvisation, micro-organisms from extreme environments, Archaebacteria, etc.

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

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

- **Morphogenesis and organogenesis in plants**

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

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

inclusion of few additional topics. Areas that need to be introduced in syllabi have been identified as:

- Extremophiles
- Bioinformatics
- Mathematical approach for Biologists
- Molecular tools for characterization and identification of bacteria
- Advanced Biochemistry techniques
- Advanced Molecular Biology Techniques
- Morphogenesis and organogenesis in plants
- Signal transduction
- Techniques in Bio-nanotechnology
- Radioisotopes in Biology and Confocal Microscopy

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

Introduction:

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

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

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Course Structure:

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

B: Workload:

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

1. For the purpose of computation of workload, the following mechanism may be adopted as per UGC guidelines:
   i) 1 Credit = 1 Theory period of one-hour duration per week
   ii) 1 Credit = 1 Tutorial period of one-hour duration per week
   iii) 1 Credit = 1 Practical period of two-hour duration per week

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

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

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

C: Credit Distribution for semester I and II

Course Structure: Semester I

Course Type	Course Code	Course Name	Credit	Assessment		
				IA	UE	Total
Core Compulsory Theory Papers	MB501	Microbial Systematics	4	30	70	100
	MB502	Quantitative Biology	4	30	70	100
	MB503	Biochemistry and Metabolism	4	30	70	100
Choice Based Optional Papers Elective/ Departmental Course	MBTE11	Fungal Systematics and Extremophiles	2	15	35	50
	MBPE11	Practicals Based on Fungal Systematics and Extremophiles	2	15	35	50
	OR					
	MBTE12	Experimental Design and Quantitative approaches for Biologist	2	15	35	50
	MBPE12	Practical's based on Experimental Design and Quantitative approaches for Biologist	2	15	35	50
	OR					
	MBTE13	Microbial communication, Membrane transport and signal transduction	2	15	35	50
	MBPE13	Practicals Based on Microbial communication, Membrane transport and signal transduction	2	15	35	50
Core Compulsory Practical paper	MBCP1	Biochemical Techniques(Practical based on compulsory theory credits)	4	30	70	100

Course Structure: Semester II

Course Type	Course Code	Course Name	Credit	Assessment		
				IA	UE	Total
Core Compulsory Theory Papers	MB601	Instrumentation and Molecular Biophysics	4	30	70	100
	MB602	Molecular Biology	4	30	70	100
	MB603	Enzymology, Bioenergetics and Metabolism	4	30	70	100
Choice Based Optional Papers Elective/Departmental Course	MBTE21	Bioinformatics and Bio-nanotechnology	2	15	35	50
	MBPE21	Practicals based on Bioinformatics and Bio-nanotechnology	2	15	35	50
	OR					
	MBTE22	Molecular Biology tools and applications	2	15	35	50
	MBPE22	Practical based on Molecular Biology tools and applications	2	15	35	50
	OR					
	MBTE23	Nitrogen Metabolism, respiration and Photosynthesis	2	15	35	50
	MBPE23	Practicals based on Nitrogen Metabolism, respiration and Photosynthesis	2	15	35	50
Core Compulsory Practical paper	MBCP2	Molecular biology, enzymology and instrumentation Techniques(Practical based on compulsory theory credits)	4	30	70	100

MB: Microbiology; PE: Practical Elective; TE: Theory Elective; CP: Compulsory Practical
Details of courses for Semester III and IV will be declared later.

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

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

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

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

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

General Instructions

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

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

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

However, the end-semester assessment shall cover the entire syllabus prescribed for the course.

An in-semester assessment of 30% marks should be continuous and at least two tests should be conducted for courses of 4 credits and a teacher must select a variety of procedures for examinations such as:

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

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

Semester end examination for remaining 70% marks will be conducted by Savitribai Phule Pune University.

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

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

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

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

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

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

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

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

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

Semester I

MB501:Microbial Systematics

Core Compulsory Theory Paper

Total: 4 Credits Workload :-15 hrs /credit

(Total Workload :- 4 credits x 15 hrs = 60 hrs in semester)

Bacterial Systematics (15)

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

Microbial Diversity (15)

1. Facets of microbial diversity: morphological, structural, metabolic, ecological, behavioral and evolutionary
2. Species divergence and measurement of microbial diversity
3. Measures and indices of diversity; alpha, beta and gamma diversity

Exploration of Un-culturable microbial diversity: (15)

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

Evolution(15)

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 multi-cellularity in microorganisms, Game theory. Co-evolutionary strategies, host parasite co-evolution

3.Molecular evolution: origin of life, the origin of new genes and proteins. ageing, evolutionary trade-offs, r and k selection

Suggested References:

1. Microbial Diversity: Form and Function in Prokaryotes, Published Online: 30 NOV 2007. DOI: 10.1002/9780470750490.ch1 Copyright © 2005 by Blackwell Science Ltd

2. Carl R. Woese. The archaeal concept and the world it lives in: a retrospective. Photosynthesis Research 80: 361 – 372, 2004. Kluver Academic Publishers.

3.Brown James. Principles of Microbial Diversity.ASM Press ,2014.

4. Ridley Mark (2004). Evolution. Blackwell Science Ltd.

5. Species Divergence and the measurement of microbial diversity. Catherine Lozupone and Rob Knight. FEMS Microbiol. Rev. 32 (2008) 557 – 578.

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

Semester I

MB502:Quantitative Biology

Core Compulsory Theory Paper

Total: 4 Credits Workload :-15 hrs /credit

(Total Workload :- 4 credits x 15 hrs = 60 hrs in semester)

Descriptive Statistics (15)

1. Fundamental concepts –Sample Statistics and Population parameter, data (qualitative and quantitative data, discrete and continuous series data), data sources, variables, measurement scales (nominal, ordinal, interval and ratio), variability and uncertainty in measurements
2. Measures of central tendency – Mean Mode, median
3. Measures of dispersion – Mean deviation Standard deviation and Variance
4. Data presentation-Tables and Graphs (Histogram, bar, pie and line)

5. Simple linear Regression and correlation *(significance testing not necessary)*
   (Sr. No. 1:- only theory questions to be asked in exam. Sr. No. 2 – 5:- only problem solving questions to be asked in exam.)

Inferential Statistics-1(15)

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.)

Inferential Statistics-2(15)

1. Test of Significance: Chi square test (Goodness of fit and Independence),
2. Comparison of 3 or more samples – ANOVA One way and two way, Post Hoc test (Tukey's)
3. Nonparametric Tests: comparison to parametric tests, Sign test, Wilcoxon's signed rank test and Mann-Whitney U test

Probability and Probability Distribution (15)

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. Bernard Rosner Fundamentals of Biostatistics,5th Ed. Duxbury Thomson
3. Wayne Daniel (2007) Biostatistics A foundation for Analysis in the health sciences,wileyIn
4. Lindgren B.W. Statistical Theory, Macmillan Publishing Co.Inc.
5. Norman T. J. Bailey Statistical methods in biology, 3rd Ed.Cambridge University Press
6. Gupta S.P. Statistical methods, Sultan Chand & Sons Publisher, New Delhi
7. Montgomery D.C. Design and analysis of experiments, John Wiley & Sons
8. Stephen Newman, Biostatistical methods in Epidemiology. Wiley Interscience Publication,
9. Aviva Petrie and Carolene Sabin, 2005, Medical Statistics at a glance, 2nd Edition, Blackwell
10. Haefner James W. (1996) Modeling Biological Systems: Principles and Applications, Kluwer Academic Publications
11. David Brown & Peter Rothery. Models in biology: Mathematics, statistics, and computing John Wiley & Sons, USA
12. Practical Fermentation Technology Edited by Brian McNeil and Linda M. Harvey 2008 John Wiley & Sons, Ltd. ISBN: 978-0-470-01434-9
13. Bioprocess Engineering Principles by Pauline M. Doran (1995), Elsevier Science & Technology Books, ISBN: 0122208552

14. Peter J. Diggle, Amanda G. Chetwynd Statistics and Scientific Method: An Introduction for Students and Researchers, Publisher: Oxford University Press, Year: 201,

Semester I

MB503:Biochemistry and Metabolism

Core Compulsory Theory Paper

Total: 4 Credits Workload :-15 hrs /credit

(Total Workload :- 4 credits x 15 hrs = 60 hrs in semester)

Protein Chemistry:(15)

Structural features of amino acids, classification of amino acids

Amino acids as buffers, Henderson Hasselbalch equation and its role in buffer formulation

Peptide linkage, partial double bond nature of peptide bond

Determination of primary structure of polypeptide (N-terminal, C-terminal determination, method of sequencing of peptides),

Structural classification of proteins: primary, secondary, tertiary, quaternary structures of proteins, Non-covalent interactions, Conformational properties of proteins, Polypeptide chain geometry, Resonance forms of the peptide group, cis/trans isomers of peptide group Ramchandran plot

Secondary, Super-secondary, Motif & Domain, Tertiary and Quaternarystructures of proteins, (Myoglobin &hemoglobin)

Biochemistry and Molecular Biology Techniques(15)

Chromatography: Principles and applications of gel filtration, Ion exchange, affinity chromatography

Electrophoresis: Agarose, Native PAGE, SDS PAGE

Polymerase chain reaction: Principle, variations of PCR (Hot start, Nested, Reverse transcription, real time PCR) and its Applications.

Sequencing methods: RNA-sequencing methods and applications, DNA sequencing: Classical and next generation sequencing methods (Pyro-sequencing, Ion torrent, Nano-pore sequencing).

Developmental Biology: (15)

Introduction to developmental biology. Different model systems used to study developmental biology

Conserved nature of development, Concepts of commitment, determination and differentiation, Morphogen gradients in developmental regulation, Hox code, MPF

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.

Morphogenesis and organogenesis in plants: Organization of shoot androot apical meristem; shoot and root development; transition to flowering,floral meristems and floral development in *Arabidopsis*.

Cell biology:(15)

Structural organization and function of Endoplasmic Reticulum, Golgi apparatus, Nucleus, Mitochondrion, chloroplast, Lysosomes, peroxisomes; Cytoskeleton and function of Molecular motors.

Protein trafficking among various cellular compartments (by secretory and cytosolic pathway: targeting to secretory vesicles, cell membrane, lysosomes, nucleus, mitochondria and peroxisomes)
Events in cell cycle, Regulation of cell cycle. Apoptosis

Suggested References:

Biochemistry

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. Moat Albert G. and Foster John W. (2002) Microbial Physiology 4th Ed. John Wiley and Sons New York.
5. Donald Voet (Author), Judith G. Voet (2011). Biochemistry, 4th Edition, Kindle Edition
6. Berg Jeremy, Tymoczko John, StryerLubert (2002) *Biochemistry* 5th Ed, W. H. Freeman, New York.
7. Carl IvarBranden, John Tooze (1999) Introduction to Protein Structure, 2nd Edition, Garland science.

Cell Biology

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

Development and Differentiation

1. Gilbert Scott F. (2010). Developmental Biology. 9th Ed. Sinauer Associates Inc. Mass. USA.
2. Muller W.A. (1997) Developmental Biology, SpringlerVerlag, New York, Inc.
3. Lewis Wolpert, Cheryll Tickle, and Alfonso Martinez Arias (2015) Principles of Development, Fifth Edition, Oxford University press

Semester I

MBTE11: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)

(30)

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.

Extremophiles

1. Enrichment, isolation, classification, properties and application of extremophiles: Thermophiles, Psychrophiles, Halophiles, Acidophiles, Methanogens
2. Adaptation mechanisms of extremophiles

Semester I

MBPE11: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)

1. Isolation and identification of yeasts and saprophytic molds from natural samples.

The identification key must be designed for each isolated and identified fungus. Students are expected to isolate at least one Genus from Mold and Yeast each

(Varied types of samples should be processed to obtain representative isolate of the groups)

2. Isolation and identification of the following extremophiles from natural samples: Acidophiles and Halophiles

Identification of the bacteria to at least the Genus level using the Bergey's Manuals is expected. The identification key must be designed for each isolated and identified bacterium. Students are expected to isolate at least one Genus from each group.

(At least 5 different types of samples should be processed to obtain isolates)

Semester I

MBTE12:Experimental Design and Quantitative approached for Biologist
Choice based Optional Theory Paper(Elective)

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

(30)

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 – single & double), controlled and uncontrolled trials

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

Semester I

MBPE12:Practicals Based on Experimental Design and Quantitative approached for Biologist

Choice based Optional Practical Paper(Elective)

Total: 2 Credits Workload :-30 hrs /credit

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

(60)

Practical's based on theory credit Designing of experiments

1. Designing of Mock Research Proposal which includes:
    a) Title
    b) Hypothesis
    c) Review of Literature
    d) Methodology *(Specify Statistical Methods)*
    e) Possible outcomes *(Statistical Interpretations)*
    f) References

Scientific writing should be followed for Research proposal

2. Epidemiological study Proposal *(Mini Project)*
    a) Identification of Problem and Establishing Hypothesis
    b) Selection of Design
    c) Data Collection
    d) Data Analysis
    e) Data Presentation
    f) Conclusion

Scientific writing should be followed for proposal

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) Conclusion of Survey

(Actual statistical survey need to be carried out to demonstrate its mechanism)

4. Factorial Study Design (Placket barmen, Fractional Factorial and full factorial) for Optimization of Media conditions
    a) Data collection from Research Papers/ Dissertations /Journals

b) Data Treatment using Statistical Software's (Mini tab, SPSS and Design Expert)

(Sr. no. 1 is compulsory, select any one from sr. no.2 to 4)

Practical's based on theory credit Mathematical approach for Biologists

1. Numerical Microbiology Problem solving: Unit conversion, Numerical Problems on size, volume, number (CFU and PFU), dilutions, Neubauer chamber, direct microscopic count, Numerical Problems on Bacterial Growth. Numerical problems on diversity indices

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

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

Semester I

MBTE13:Microbial communication, Membrane transport and signal transduction
Choice based Optional Theory Paper(Elective)

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

(30)

Communication and Coordination among microorganisms

Life cycle of *Dictyosteliumdiscoideum*, Molecular mechanism of quorum sensing in slime moulds,
Life cycle of myxobacteria, Molecular mechanism of quorum sensing in myxobacteria.
Quorum sensing in Gram positive and Gram-negative bacteria,
Biofilms, their organization, signals involved in their formation and dispersal, applications of study on biofilms in pathogenic and non-pathogenic environments

Membrane transport and signal transduction

The composition and architecture of membranes, Membrane dynamics,
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, Liposomes and model membranes,
Signal transduction pathways in bacteria, second messengers, regulation of signaling pathways, bacterial two-component systems, chemotaxis.

Suggested References

Communication and Coordination among microorganisms

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

Semester I

MBPE13:Practicals Based on Microbial communication, Membrane transport and signal transduction

Choice based Optional Practical Paper(Elective)

Total: 2 Credits Workload :-30 hrs /credit

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

Communication And Coordination among microorganisms

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

Membrane transport and signal transduction

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

Semester I

MBCP1:Biochemical Techniques

Core Compulsory Practical Paper

Total: 4 Credits Workload :-30 hrs /credit

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

1. Safety rules in Laboratory: Laboratory safety, hazard from chemicals, handling of chemicals, disposal of chemicals and cultures, recording of scientific experiments. Standardization of laboratory procedures, calibration and validation instruments, preparing / designing SOP for the same, maintenance of instruments

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

Preparation of buffers using $KH_2PO_4$and K_2HPO_4, acetic acid and sodium acetate, K_2HPO_4 and H_3PO_4.

3. Computer applications: Using data sheets, and sorting data with different parameters, plotting graphs – bar charts, line graphs, pie charts, adding error bars. (Using Microsoft Excel)

Statistical analysis of data – Students t test, ANOVA, Chi square test, F test using computer softwares (Using Microsoft Excel)

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

Identification of the bacteria to at least the Genus level using the Bergey's Manuals is expected. The identification key must be designed for each isolated and identified bacterium. 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)

5. Studying the stages mitosis in growing tip of onion root cells and to observe polyploidy induced by colchicine treatment on root tip.

6. Demonstration of mounting of embryos (frog and fruit fly) at various developmental stages on permanent slides

7. Extraction of Protein and Exo-polysaccharide from bacterial culture(may use TCA and ethanol method)

8. Colorimetry and spectrophotometry: estimation of above sample: Bradford and UVSpectrophotometry (purity using A_{280} method).

9. Chromatography: Separation of hydrolysed protein and EPS sample (above) using paper and thin layer chromatography. (*Explain concept of two-dimensional chromatography and descending chromatography*)

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

11. Interpretation of Ramchandran Plot and study of conformations of protein molecule using

Molecular Graphics Visualization Tool (e.g. Swiss PDB)

Semester II

MB601:Instrumentation and Molecular Biophysics

Core Compulsory Theory Paper

Total: 4 Credits Workload :-15 hrs /credit

(Total Workload :- 4 credits x 15 hrs = 60 hrs in semester)

(15)

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 HighPerformance 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)

Spectroscopy

Introduction: Electromagnetic spectrum, Atomic orbitals, Molecular orbitals, Electronic, Rotational and Vibrational transitions in spectroscopy, Interpretation of spectra.

1. UV/Visible spectroscopy- Instrumentation, Molar Absorptivities, Beer and Lamberts Law, Bathochromic and hypochromic shifts.
2. Fluorescence spectroscopy- Instrumentation, Quantum Yield, Quenching, FRET, Binding and Folding studies, Flow cytometry and FACS
3. Infrared spectroscopy- Principle, Instrumentation, Absorption bands, FTIR and its applications
4.Mass spectroscopy- Principles of operation, Ionization, Ion fragmentation, Mass Analysers, GC-MS, MALDI-TOF

(15)

Biophysical Techniques

1. NMR spectroscopy: Basic Principles of NMR, Chemical shift, Intensity, Line width, Relaxation parameters, Spin coupling, Nuclear Overhauser Effect Spectroscopy, Correlation Spectroscopy, Approach to structure determination by 2D-NMR

2. X-ray crystallography: Purification of proteins, Crystallization of proteins, Instrumentation, acquisition of the diffraction pattern, basic principles of x-ray diffraction, Crystal Structures (Bravais Lattices), Crystal planes and Miller Indices, Fourier Transform and Inverse Fourier, Direct Lattice

and Reciprocal lattice, Ewald sphere, Electron density Maps, Phase determination

(15)

Radioisotopes in Biology and Confocal Microscopy

1. Radioisotopes in Biology:
- Principles and applications of radio tracers in medicine, agriculture, industry, and fundamental research
- Radiation and Radioactive isotopes: Types, Quantities and units of estimation, half-life of isotopes
- Detection and measurement of radioactivity- Autoradiography, Liquid scintillation counting.
- Effect of radiation on biological system

2. **Confocal Microscopy**: scanning optical microscope, confocal principle, resolution and point spread function, light source: gas lasers & solid-state, primary beam splitter; beam scanning, pinhole and signal channel configurations, detectors; pixels and voxels; contrast, spatial sampling: temporal sampling: signal-to noise ratio, multichannel images

Suggested References

1. Clive Dennison (2002) *A guide to protein isolation*, Kluwer Academic Publishers
2. Pattabhi, V. and Gautham, N. (2002) *Biophysics.* Kluwer Academic Publishers, New York and Narosa Publishing House, Delhi.
3. David J Holme, Hazel Peck (1998) *Analytical Biochemistry*, 3rd Ed. Prentice Hall, Pearson Education Limited, Harlow England.
4. Rodney F. Boyer (2000*) Modern Experimental Biochemistry*3d edition., Benjamin Cummings.
5. Nölting, B. (2006) *Methods in modern biophysics.* Second Edition. Springer, Germany.
6. Wilson Keith and Walker John (2005) *Principles and Techniques of Biochemistry and Molecular Biology*, 6th Ed.Cambridge University Press, New York.
7. Rolf Ekman, Jerzy Silberring, Ann Westman-Brinkmalm, AgnieszkaKraj (2009) *Mass spectrometry: instrumentation, interpretation, and applications*, John Wiley &Sons,Inc.,Canada.
8. Irwin H. Segel (1976) *Biochemical Calculations: How to SolveMathematical Problems in General Biochemistry*, 2nd Edition.John Wiley & Sons.
9. Mount, D. W. (2001) *Bioinformatics: sequence and genomeanalysis.* Cold Spring Harbor Laboratory Press, New York.
10. David M Webster (2000) *Protein Structure Prediction-Methods and Protocols*, Methods In Molecular Biology Vol143 Humana Press.
11. Narayanan, P. (2000) Essentials of Biophysics. New Age International Publication, New Delhi.
12. Christof M. Niemeyer and Chad A. Mirkin (2006) *Nanobiotechnology*, John Wiley & Sons.
13. Daniel L. Feldheim and Colby A. Foss, Jr. *(2002) Metal nanoparticles synthesis and characterization and applications* Marcel Dekker, Inc.
14. MahendraRai and Nelson Duran (2011) *Metal nanoparticles in Microbiology*, Springer Verlag Berlin Heidelberg.
15. Sohier, J., Laurent, C., Chevigné, A., Pardon, E., Srinivasan, V., Wernery, U. Galleni, M. (2013). Allosteric Inhibition of VIM Metallo-β-Lactamases by a

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

MB602:Molecular Biology

Core Compulsory Theory Paper

Total: 4 Credits Workload :-15 hrs /credit

(Total Workload :- 4 credits x 15 hrs = 60 hrs in semester)

(15)

RNA processing &Molecular Techniques

1. RNA Processing: Eukaryotic
   - mRNA splicing (Spliceosome and auto splicing by Intron I and Intron II), rRNAprocessing,tRNAprocessing, RNA Editing,
   - Nuclear export of mRNA
   - Regulatory RNAs and noncoding RNAs : Si RNA, Micro RNA, RNAi
   - Pi RNA (PIWI interacting RNAs)
2. Molecular Techniques
   Knockoutmice,phagedisplay, expressed sequence tags, Yeast two and three hybridassay, Activitygelassay,DNA helicase assay, Chromatin Immuno-precipitation (ChIP),Designingprobe, Epitopetagging

(15)

Tools for Genetic engineering

1. Restriction endonucleases and methylases; DNA ligase, klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labeling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence *in situ* hybridization.
2. Vectors for cloning and gene expression: Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Blue script vectors, *Baculovirus* and *Pichia* vectors, plant-based vectors (Ti and Ri as vectors). Vectors for gene expression: types (pMal, GST, pET-based vectors), Protein purification (His-tag, GST-tag, MBP-tag)
3. Construction of cDNA and genomic libraries

(15)

Genome projects

1. Concept and meaning of genome projects and their applications
2. Introduction to Genome projects of *E. coli*, yeast, Plasmodium, Mouse, Drosophila, and Rice and comparative genomics
3. Gene annotation
4. Human Genome project and its applications

(15)

Moleculardiagnostics 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

Suggested References

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

Semester II

MB603:Enzymology, Bioenergetics and Metabolism

Core Compulsory Theory Paper

Total: 4 Credits Workload :-15 hrs /credit

(Total Workload :- 4 credits x 15 hrs = 60 hrs in semester)

(15)

Enzymology

1.Purifications of enzyme, purification chart,

2.Kinetics of reversible inhibitions: Competitive, uncompetitive, non-competitive, mixed, substrate. Primary and secondary plots, Determination of Ki using secondary plots. Significance of inhibitors

3.King Altman approach to derive – two substrate enzyme catalysed reactions

4.Concept of allosterism, positive and negative co-operativity, models of allosteric enzymes (Monad, Wyamann and Changuax and Koshland, Nemethy and Filmer model), kinetics of allosteric enzyme, Hill plot, examples of allosteric enzymes and their significance in regulation.

(15)

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)

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 sacid) and fats in animals
7. Lipids as signal molecules (eg. phosphatidyl inositol, eicosanoids).

(15)

Carbohydrate Chemistry and Metabolism

1. Mono, di, oligosaccharides and polysaccharides, with examples
2. Isomerism in sugars: asymmetric centres in sugars, dextro, leavo-rotatory, sugar anomers (reducing and non-reducing sugars), sugar epimers
3. Sugar derivatives such as sugar alcohols, amino sugars, sugar acids, deoxy sugars
4. Glycolysis and gluconeogenesis, Regulation of glycolysis and gluconeogenesis,
5. Synthesis of microbial exopolysaccharides (alginate)
6. Cellulose synthesis and breakdown
7. Regulation of Glycogen synthesis; breakdown,
8. Metabolic flux and its regulation by various metabolic intermediates,
9. TCA cycle- regulation, role in energy generation, Role in generating biosynthetic intermediates and glyoxylate cycle

Suggested References:

1. Nelson D. L. and Cox M. M. (2005) Lehninger's Principles of Biochemistry, Fourth edition, W.H. Freeman & Co. New York.

2. Palmer Trevor (2001) Enzymes: Biochemistry, Biotechnology and Clinical chemistry, Horwood Pub. Co. Chinchester, England.

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

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

5. Michael T. Madigan, John M. Martinko, David A. Stahl, David P. Clark (2012) Brock Biology of Microorganisms, Thirteenth edition, Benjamin Cummings, San Francisco.

6. Moat Albert G. and Foster John W. (1988) Microbial Physiology 2nd Ed. John Wiley

7. Berg Jeremy, Tymoczko John, StryerLubert (2001) Biochemistry 4th Ed, W. H. Freeman, NY

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

Semester II

MBTE21: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)

(30)

Bioinformatics

1. Introduction and biological databases Nucleic acid, proteins, genomes— structure data bases, search engines, sequence data forms and submission tools, scoring matrices for sequence alignments, algorithmspairwise 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)

Techniques in Bio-nanotechnology

1. Biogenic nanoparticles – Synthesis and applications. Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Role of plants in nanoparticle synthesis.
2. Significance of the physical properties of nanoparticles
3. Characterization of nanoparticles Dynamic Light Scattering (DLS), EDAX analysis, Zeta analysis
4. Imaging techniques to characterize nanoparticles: Principle, instrumentation and applications of

- TEM (Transmission Electron Microscope)
- SEM (Scanning Electron Microscope)
- Scanning Probe Microscopy (SPM)
- AFM (Atomic Force Microscopy)

Semester II

MBPE21:Practicals 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)

(60)

Bioinformatics

16S rRNA gene sequencing analysis of bacteria:

- Isolation, purity checking using A_{260}/A_{280} ratio and Agarose gel electrophoresis of isolated chromosomal DNA of bacteria
- PCR amplification and purification of 16S rRNA gene
- Demonstration of the following steps, if not possible to perform in your lab: PCR product Sequencing using automated sequencer
- Sequence matching by BLAST analysis.
- Drawing phylogenetic tree using related sequences (Using standard software like Phylip, Mega etc)

Bionanotechnology

1.Biological synthesis of nanoparticles(at least 2 types) using **actinomycetes /fungi /yeast** and their characterization by UV-Vis spectroscopy
Characterisation of nanoparticles, Antimicrobial activity, dye decolorization activity, etc

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

- Extract preparation
- Synthesis of nanoparticles
- UV/vis spectroscopy
- and their characterization by UV-Vis spectroscopy, Characterization of nanoparticles, Antimicrobial activity, dye decolorization activity, etc

3. Nanoparticle characterization data analysis(data to be obtained from scientific literature)

- SEM/TEM/AFM images,FTIR scan, DLS,zeta potential, etc.

Semester II

MBTE22: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)

(30)

Tools in Molecular Biology

1. Study of protein-DNA interactions: electrophoretic mobility shift assay; DMS foot printing, DNase foot printing; methyl interference assay, protein-protein interactions using yeast two-hybrid system; phage display.
2. DNAmicroarray, Construction of microarrays – genomic arrays, cDNA arrays and oligo arrays
3. Super shift assay and EMSA,Sequencetaggedsites,Filter bindingassay, Proteinfootprinting,findingthereplicon,DNAfingerprinting, Measuring transcription rates
4. Hybridization techniques: Free solution, membrane based (DOT blot,SLOT blot), Fluorescence in situ hybridization (FISH) and Microarraytechnology,
5. CRISPR-Cas system: Technology and Applications

ApplicationsofrecombinantDNAtechnology–

Application of RDT in Production of SecondaryMetabolites

1. Synthesis of commercial products: Amino acids (L- Valine and L-cysteine), ascorbicacid,Polyketideantibiotics,
2. Hybrid Human-Mouse monoclonal antibodies, Human monoclonal antibodies, anticancer antibodies
3. Biopolymers:gum,rubber,polyhydroxyalkanoates.
4. Un-conventionalmicrobialsystemsforproductionof high-quality proteindrugs.

Semester II

MBPE22: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)

1. Cloning and transformation using plasmid vectors- GFP gene cloning /blue and white screening
   - Vector and Insert Ligation,
   - Preparation of competent cells
   - Transformation of *E. coli* with standard plasmids,
   - Calculation of transformation efficiency
2. PCR amplification and purification of 16S rRNA gene
3. PCR Primer Design
4. Protoplast fusion
5. Activity staining analysis (Zymograms) (NATIVE PAGE)
6. FTIR analysis of a biomolecule/recombinant molecule (at least five different molecules)
7. Production by recombinant strain and estimation of Biopolymers:
   a) Gum
   b) Polyhydroxyalkanoates (PHB)

Semester II

MBTE23:Nitrogen Metabolism, respiration and Photosynthesis
Choice based Optional Theory Paper(Elective)

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

(30)

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

Respiration and photosynthesis

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.

Photosynthesis:

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

Semester II

MBPE23:Practicals based on Nitrogen Metabolism, respiration and Photosynthesis
Choice based Optional Practical Paper(Elective)

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

1. Isolation of IAA producing organism, Detection of Indole acetic acid production by microorganism
2. Detection of siderophore production by microorganism
3. Enrichment ,Isolation and characterisation of nitrogen fixing activity of bacteria
4. Extraction and estimation of a) polyphenols, b) tannins by FolinDanis method
5. Enrichment and isolation of lignin/xylan degraders from Soil
6. Enrichment, Isolation and characterisation of Sulphur reducing bacteria/Methanogens.
8. Enrichment, Isolation and characterization of Cyanobacteria.
9. Detection of chlorophyll-a activity of Cyanobacteria

Semester II

MBCP2: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. Plasmid DNA isolation, DNA quantitation and characterization by gel electrophoresis.
3. Construction of restriction digestion map of plasmid DNA
4. Curing of bacterial Plasmid
5. Gene annotation
6. Purification of enzymes (Amylase/Invertase): (ammonium sulphate precipitation, organic solvent precipitation, gel filtration, etc.) (Any two Methods)Establishment of enzyme purification chart
7. Determination of Km, Vmax and Kcat values of enzyme
8. Determination of molecular extinction coefficient of biomolecule
9. Isolation of Aflatoxin producing organism. Extraction and Detection of Aflatoxin in food.
10. Isolationand characterization of lipase/cellulase/chitinaseproducing microbe.
11. Scientific Communication and Research Methodology

    Concept of effective communication: Presentation skills, formal scientificpresentation skills; Preparing power point presentation, Presenting the work,Scientific poster preparation &oral presentation; Participating in groupdiscussions. Technical writing skills: Types, Formats of scientific reports, scientificwriting skills, Significance of communicating science, ethical issues, copyrights and plagiarism, Components of a

research paper, publishing scientificpapers - 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).

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