Anekant Education Society's

Tuljaram Chaturchand College, Of Arts, Science & Commerce Baramati – 413102

(Autonomous)

Syllabus (CBCS) for M.Sc. Microbiology

w.e.f. June 2022

Preamble:

Overall picture of student trends (before undergraduate studies) in selecting courses is very typical; most of the science students aim at professional courses, particularly leading to studies in Engineering. Comparatively a smaller number of students opts for degrees in Biosciences. For several years now, the first preference of students desiring to enter the field of Life Sciences has been Microbiology, and for last 2 to 3 years it has shifted partly to Biotechnology courses. Both these disciplines viz. Microbiology and Biotechnology deal with overlapping interests. Microbial sciences focus more on study of the microbial world (this limitation needs to be corrected!) While Biotechnology focuses more on application of mammalian systems. The main theme of teaching these courses, however, remains the same i.e., application of basic principles of Life Science 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 Board of Studies in Microbiology has identified the following thrust areas and prospective plans for syllabi reforms at postgraduate level:

Microbial Technology – includes application of bacteria, fungi, protozoa and viruses in traditional (food, dairy, wine, antibiotics, fermentation, etc.) and biotechnological industries.

Human health – includes pathogenic micro-organisms (bacterial, viral, protozoan and fungal), therapeutics and pharmaceutical approach towards diseases, diagnostics, vaccine developments, epidemiological characterization of diseases, gene therapy, etc.

Agriculture – includes biofertilizers and biocontrol, ecology and geomicrobiology.

Environment – includes cleaner processes that produce less waste and use less energy and water in such industrial sectors as chemicals, pulp and paper, textiles and dyes, food, energy, and metals and minerals, harnessing microbial utilities avoiding the use of caustic chemicals, bioremediation and bioprospecting

Microbial diversity – includes collecting information of diversity, exploration and utilization of diversity to identify and harvest biomolecules for human health improvisation, micro-organisms from extreme environments, Archeabacteria, etc.

Research in life-sciences – includes research tools like immunology and molecular biology, developmental biology, evolution, stem cell research, etc. 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:

- Eukaryotic cellular organization
- Eukaryotic gene expression e.g., yeast genetics
- Determinants of microbial pathogenicity
- Immunopathology, immunopharmacology and cancer biology
- Protein stability, conformation and folding
- Over-expression of recombinant proteins
- Biocontrol
- Bioinformatics
- Molecular tools for characterization, identification of bacteria
- Possible utilization of microbial population from extreme environments

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.

Introduction:

The syllabi till today had been sufficient to cater for the needs of students for building up their careers in industry and research. However, 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 stressed, such that a post-graduate student can start work directly in applied fields (Industry or institutions), without any additional training. Thus, the college itself will be developing the trained and skilled man-power. We even find a lack of trained teachers who can share their experiences on different aspects in microbiology. And we plan to restructure 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) with technological disciplines to produce goods and services and for environmental management.

Eligibility

B. Sc. with Principle subject Microbiology.

Duration of Course – Two years.

External students – There shall be no external students.

Workload:

There shall be 15 contact hours per credit (1 hour / credit / week), out of which classroom teaching hours will be 11 and 4 contact hours for preparation of in-semester continuous assessment.

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Course Structure for M.Sc. - I: Microbiology

Semester	Paper Code	Title of Paper	No. of Credits
I	**PSMB111**	Microbial Systematics and Diversity	**4**
	PSMB112	Quantitative Biology	**4**
	PSMB113	Biochemistry	**4**
	PSMB114	Cell Biology	**4**
	PSMB115	Practical Course: Microbial Systematics	**4**
	PSMB116	Practical Course: Cell biology and Biochemistry	**4**
	HR 1	Human Rights Awareness Course	**2**
	CYS I	Introduction to Cyber Security – I	**2**
		Total Credits	**28**
II	**PSMB121**	Virology	**4**
	PSMB122	Instrumentation	**4**
	PSMB123	Metabolism	**4**
	PSMB124	Evolution and Ecology	**4**
	PSMB125	Practical Course: Biophysics & Virology	**4**
	PSMB126	Practical Course: Enzymology & Microbial Metabolism	**4**
	CYS II	Introduction to Cyber Security – II	**2**
	CC40	**Research Methodology**	**2**
		Total Credits	**28**

Course Structure for M.Sc. - II: Microbiology

Semester	Paper Code	Title of Paper	No. of Credits
III	**PSMB231**	Immunology	**4**
	PSMB232	Molecular Biology I	**4**
	PSMB233	Industrial Waste Water Treatment	**4**
ELECTIVE	**PSMB234A**	Biophysical Techniques	**4**
	PSMB234B	Developmental Biology	**4**
	PSMB235	Practical Course: Practical course based on Immunology, Pharmaceutical Microbiology and Industrial waste water treatment	**4**
	PSMB236	Practical Course: Practical course based on Molecular Biology (I and II) and Microbial Technology	**4**
	SD 23	Skill Development I	**2**
		Total Credits	**26**
IV	**PSMB241**	Pharmaceutical Microbiology	**4**
	PSMB242	Molecular Biology II	**4**
	PSMB243	Microbial Technology	**4**
ELECTIVE	**PSMB244A**	Medical Microbiology	**4**
	PSMB244B	Mathematics for Biological Science	**4**
	PSMB245	Dissertation I	**4**
	PSMB246	Dissertation II	**4**
	SD 24	Skill Development II	**2**
		Total Credits	**26**

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2022)
Academic Year 2022-2023

Class: M. Sc. I (Semester- I)
Paper Code: **PSMB111**
Paper: I
Title of Paper: Microbial Systematics and Diversity
Credit: 4
No. of lectures: 60

Course Objectives:

1. To introduce the concept of Bacterial taxonomy.
2. To expand the knowledge of unculturable bacteria.
3. To enrich students' knowledge about Next generation Sequencing.
4. To expand the knowledge of microbial diversity.
5. To introduce the various bioinformatics tools to study the concept of sequencing.
6. To introduce students' various methods of extracting total bacterial DNA from a habitat.
7. To help student's build-up a progressive and successful career.

Course Outcome:

CO1. Acquire basic skills on bioinformatics tools to study the taxonomy.
CO2. Introduce the concepts of application and research in Microbiology.
CO3. Students will be able to estimate total number of species.
CO4. Students will gain knowledge of species divergence and would be able to measure microbial diversity.
CO5. Students will be able known Bergey's Manuals and use it for classification of prokaryotes.
CO6. Students will gain knowledge of 16S rRNA gene sequencing and its importance in identifying bacteria.
CO7. Students will be able to acquire knowledge to identify Culture by Next generation Sequencing.

UNIT 1: Taxonomy of Bacteria and Introduction to Bergey's Manuals (15L)

- Introduction to Bacterial Taxonomy
- Science of classification
- The 5-Kingdom classification system
- The 3-Domain classification system
- Bergey's Manuals and the classification of prokaryotes.
- Determinative Bacteriology (Phenetic Approach)
- Systematic Bacteriology (Phylogenetic Approach Polyphasic Approach)

UNIT 2: Microbial diversity (15L)

- The expanse of microbial diversity
- Estimates of total number of species
- Species Divergence and the measurement of microbial diversity.
- Measures and indices of diversity.

UNIT 3: Exploration of Un-culturable bacteria (15L)

- Concept of 'unculturable' bacteria and its diversity.
- Strategies for culture of 'unculturable' bacteria.
- Culture independent molecular methods for identifying unculturable bacteria.
- Methods of extracting total bacterial DNA from a habitat and metagenome analysis.
- Approaches to identify Culture -NGS (Next generation Sequence)

UNIT 4: Tools of bioinformatics (15L)

- 16S rRNA gene sequencing
- Sequence alignment: Local and Global alignment, Multiple sequence alignment
- Homology modelling
- Examples of related tools (FASTA, BLAST, BLAT)

Text / Reference Books:

1. Breed and Buchanan. Bergey's Manual of Determinative Bacteriology. 8th Edition, 1974.
2. Breed and Buchanan. Bergey's Manual of Determinative Bacteriology. 9th Edition, 1982.
3. Breed and Buchanan. Bergey's Manual of Systematic Bacteriology. 2nd Edition, (Volumes. 1 –5) (2001 – 2003).
4. Sykes, G. and F. A. Skinner (Eds). Actinomycetales: Characteristics and Practical Importance. Society for Applied Bacteriology Symposium Series No. 2, Academic Press. 1973.
5. Jacquelyn G. Black (2013) Microbiology: Principles and Explorations, 6th Edition, John Wiley & Sons, Inc.,
6. Species Divergence and the measurement of microbial diversity. Catherine Lozupone and Rob Knight. FEMS Microbiol. Rev. **32** (2008) 557 – 578
7. Methods of studying soil microbial diversity. Jennifer Kirk *et al*, (2004). Journal of Microbiological Methods **58**, 169 – 188.
8. Keller M. and Zengler K. (2004) Tapping in to Microbial Diversity. Nature Reviews 2, 141-150.
9. Pace N. (1997) A Molecular View of Microbial Diversity and the Biosphere, Science, 276, 734- 740.
10. Woese C. (1987), Bacterial Evolution. Microbiological Reviews, 221-271.
11. Michael S. Rappe and Stephen J. Giovannoni (2003). The Uncultured Microbial Majority, Annual Review of Microbiology, 57: 369 – 94.
12. Rakesh Sharma, Ravi Ranjan, Raj Kishor Kapardar and Amit Grover (2005). 'Unculturavble' bacterial diversity: An untapped resource. Current Science, 89 (1).
13. Sonia R. Vartoukian, Richard M. Palmer and William G. Wade (2010). Strategies for culture of 'unculturable' bacteria. Minireview, FEMS Microbiol Lett 309, 1 – 7.
14. James D. Oliver (2005). The Viable but Nonculturable State in Bacteria (2005). The Journal of Microbiology, 43, Special Issue, 93 – 100.
15. Jacquelyn G. Black (2013) Microbiology: Principles and Explorations, 6th Edition, John Wiley & Sons, Inc.,
16. Microbial Diversity: Form and Function in Prokaryotes, Published Online: 30 NOV 2007. DOI: 10.1002/9780470750490.ch1 Copyright © 2005 by Blackwell Science Ltd
17. Carl R. Woese. The archaeal concept and the world it lives in: a retrospective. Photosynthesis Research 80: 361 – 372, 2004. Kluver Academic Publishers.
18. Ridley Mark (2004). Evolution. Blackwell Science Ltd.

19. Wilson keith and walker jhon (2005) principles and techniques of biochemistry and molecular biology , 6th edition Cambridge university press, newyork

Mapping of course outcomes and programme outcomes:

Weightage: 1= weak or low relation, 2= Moderate or partial relation, 3= Strong or direct relation

	Programme Outcomes (POs)								
Course outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3			3	3	3			
CO2	3	3	3		3				
CO3	3	2			3		3		3
CO4	3			2					
CO5	3					2		3	
CO6	3	3	2						2
CO7	3		3					2	3

Justification for the mapping

PO1 **Disciplinary Knowledge:**

CO1: It focuses on developing specific skills in bioinformatics, needed for taxonomy studies within microbiology.

CO2: It introduces students to the broader concepts of applying microbiological knowledge and engaging in research, contributing to a deeper understanding of the discipline

CO3: Involves quantitative skills and understanding of species estimation methods.

CO4: Focuses on understanding species divergence and measuring microbial diversity.

CO5: Involves familiarity with taxonomic resources, contributing to knowledge in the discipline of microbiology.

CO6: Emphasizes knowledge of advanced molecular techniques, specifically 16S rRNA gene sequencing, contributing to the understanding of microbial identification within the discipline.

CO7: Focuses on knowledge related to advanced sequencing methods, aligning with the discipline's advancements in microbial identification

PO2 **Critical Thinking and Problem Solving:**

CO3: Involves critical evaluation of estimation methods and problem-solving skills to choose appropriate approaches based on context.

CO4: Understanding species divergence and measuring diversity require critical analysis and problem-solving to interpret complex biological data.

CO6: Understanding the significance of 16S rRNA gene sequencing involves critical thinking about molecular techniques and problem-solving in the context of bacterial identification

PO3 **Social competence**

CO2: Encourages students to engage in research, which often involves collaboration and communication with peers, professors, and potentially other researchers or

professionals

CO6: Understanding molecular techniques often requires collaboration in a research context, contributing to social competence through effective communication and teamwork

CO7: Involves staying updated on advanced sequencing methods, which may require interactions with peers, professors, or experts, enhancing social competence.

PO4 **Research-related skills and Scientific temper:**

CO1: Encourages a scientific approach to understanding and classifying microorganisms through the use of tools and methods..

CO4: Understanding species divergence and measuring microbial diversity are key research-related skills in microbiology.

PO5 **Trans-disciplinary knowledge:**

CO3: Estimating the total number of species may involve principles from ecology, statistics, and biodiversity studies.

CO4: Understanding species divergence and measuring microbial diversity integrates concepts from genetics, ecology, and bioinformatics.

PO6 **Personal and professional competence:**

CO1: Acquiring bioinformatics skills contributes to professional competence in students, as it enhances the technical abilities needed in the field. It may also foster a sense of personal accomplishment in students.

CO5:Using taxonomic resources enhances professional competence in students in classification skills, and it contributes to personal growth through the acquisition of specialized knowledge.

PO7 **Effective Citizenship and Ethics:**

CO3: Estimating the total number of species contributes to effective citizenship by fostering an understanding of biodiversity and emphasizing the ethical considerations of biodiversity conservation.

PO8 **Environment and Sustainability:**

CO5: Proper classification and understanding of microorganisms are crucial for environmental monitoring and the sustainable management of microbial resources

CO7: Acquiring knowledge of advanced sequencing methods is important in environmental genomics, contributing to sustainable practices in understanding microbial communities in various ecosystems.

PO9 **Self-directed and Life-long learning:**

CO3: Estimation methods involve quantitative skills that may require ongoing learning and refinement. Students are encouraged to seek additional knowledge and stay updated on estimation techniques.

CO6: Knowledge of advanced techniques encourages a mindset of continuous learning, as technologies evolve

CO7: Acquiring knowledge of next-generation sequencing highlights the importance of keeping abreast of technological advancements. Encourages a proactive approach to staying current in the field.

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2022)
Academic Year 2022-2023

Class: M. Sc. I (Semester- I)
Paper Code: **PSMB112**
Paper: II
Title of Paper: Quantitative Biology
Credit: 4
No. of lectures: 60

Course objective:

1. Attain a comprehensive grasp of fundamental statistical concepts encompassing probability, hypothesis testing, estimation, sampling techniques, and study design.
2. Acquire proficiency in summarizing and depicting data through measures like mean, median, mode, variance, standard deviation, and graphical representations.
3. Achieve mastery in inferential methods to draw predictions or conclusions about a population based on sample data, involving confidence intervals, hypothesis testing, and regression analysis.
4. Cultivate the ability to critically assess and interpret statistical outcomes within the framework of biological and health sciences, while acknowledging their limitations and implications.
5. Develop the capacity to communicate statistical findings effectively to non-statistical audiences via clear, succinct reporting, visualization, and explanation of results.

Course outcome:

After completing this course Students should able to:

CO1. Attain a comprehensive grasp of fundamental statistical concepts and principles relevant to the biological and health sciences.
CO2. Describe and elucidate various techniques employed in biostatistics for collecting data.
CO3. Describe and explicate various study design methods and sampling techniques utilized in biostatistics.
CO4. Apply suitable statistical techniques proficiently to analyze datasets pertaining to biological and health-related information.
CO5. Interpret statistical outcomes adeptly, extracting meaningful conclusions and insights pertinent to biological and health-related contexts.
CO6. Exercise critical evaluation skills to assess the credibility and dependability of statistical methodologies utilized in biostatistics research studies.
CO7. Communicate statistical findings effectively to diverse audiences, including non-statistical professionals, employing clear, concise language, visual aids, and appropriate documentation.

UNIT 1: Introductory Biostatistics (15L)

- Importance of statistics in Biology
- Samples and Population
- Types of data
- Random sampling methods and sampling errors
- Scales and Variables
- Collection and organization of data

- Tabulation
- Graphical representation (Histogram, frequency polygon and ogive curves)
- Diagrammatic representation (Simple bar diagram, percentage bar diagram, multiple bar diagram, sub-divided bar diagram and pie diagram).

UNIT 2: Descriptive Statistics (15L)
(No descriptive questions to be asked in examination; only appropriate problems should be asked in the examination.)

- Measures of central tendency – Mean (arithmetic, geometric, harmonic), median, Percentile and mode
- Measures of dispersion – Mean deviation Standard deviation and Variance
- Measures of skewness
- Measures of kurtosis
- Regression and correlation

UNIT 3: Probability and Probability Distributions (15L)
(No descriptive questions to be asked in examination; only appropriate problems should be asked in the examination.)

- Concept of experiment
- Concept of event (mutually exclusive & non-exclusive events, dependent & independent events)
- Laws of probability (addition and multiplication)
- Probability distribution – Normal (x-scale and z- scale), Binomial and Poisson distributions.

UNIT 4: Testing of Hypothesis (15L)
(No descriptive questions to be asked in examination; only appropriate problems should be asked in the examination.)

- Equality of two population means: t-tests and z-test,
- F-test
- ANOVA
- χ^2 (chi square) test - test for goodness of fit, independence and homogeneity

Text / Reference Books:

1. Goon, Gupta and Dasgupta Fundamentals of statistics, World Press, Kolkata.
2. Gupta S.P. Statistical methods, Sultanchand & Sons Publisher, New Delhi.
3. Irfan Ali Khan and Atiya Khanum, Fundamentals of Biostatistics. 3rd Ed. Ukaaz, Publications, Hyderabad.
4. Lindgren B.W. Statistical Theory, Macmillan Publishing Co. Inc.
5. Wayne Daniel (2007) Biostatistics A foundation for Analysis in the health sciences, Edition 7, Wiley- India edition.
6. Bernard Rosner Fundamentals of Biostatistics,5th Ed. Duxbury Thomson
7. Norman T.J.Bailey Statistical methods in biology, 3rd Ed. Cambridge University Press

Mapping of Program Outcomes with Course Outcomes

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	3							2
CO 2	2	2			2				3
CO 3	2	2							3
CO 4	3	3		3					2
CO 5	3	3							2
CO 6	2	3		2		2	2		2
CO 7	3	2	2						3

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Grasp statistical concepts: Understanding fundamental statistical concepts in biological and health sciences directly contributes to disciplinary knowledge by providing a foundational understanding of statistics in these fields.

CO2: Techniques in data collection: Describing techniques in data collection contributes partially to disciplinary knowledge by introducing methods used specifically in biostatistics, broadening the understanding within the discipline.

CO3: Study design methods: Describing study design methods and sampling techniques partially contributes to disciplinary knowledge by introducing the methodologies commonly utilized in biostatistics within biological and health sciences.

CO4: Apply statistical techniques: Proficiently applying suitable statistical techniques to analyze biological and health-related datasets significantly contributes to disciplinary knowledge in employing statistical tools in these fields.

CO5: Interpret statistical outcomes: Adeptly interpreting statistical outcomes and deriving meaningful conclusions directly enhances disciplinary knowledge by employing statistical results to draw insights in biological and health contexts.

CO6: Critical evaluation skills: The exercise of critical evaluation skills partially contributes to disciplinary knowledge by assessing the credibility of statistical methodologies used in biostatistics research studies within these fields.

CO7: Communicate statistical findings: Effectively communicating statistical findings to diverse audiences enhances disciplinary knowledge by disseminating statistical insights and conclusions to non-statistical professionals in the biological and health sciences.

PO2: Critical Thinking and Problem Solving

All Cos: Each Course Objective involves critical thinking and problem-solving skills in understanding, applying, and evaluating statistical methodologies, aligning directly with the program outcome.

PO3: Social competence

CO7: Communicate statistical findings: Communicating statistical findings to diverse audiences involves social competence by effectively conveying complex statistical information to various stakeholders in a comprehensible manner.

PO4: Research-related skills and Scientific temper

CO4: Apply statistical techniques: Proficiently applying statistical techniques significantly contributes to research-related skills by utilizing statistical tools effectively in analyzing biological and health-related datasets.

CO6: Critical evaluation skills: The exercise of critical evaluation skills partially contributes to research-related skills by assessing the reliability of statistical methodologies used in biostatistics research studies.

PO5: Trans-disciplinary knowledge
CO2: Techniques in data collection: Describing techniques in data collection contributes partially to trans-disciplinary knowledge by introducing methods utilized specifically in biostatistics, expanding the understanding across disciplines.

PO6: Personal and professional competence
CO6: Critical evaluation skills: Developing critical evaluation skills partially contributes to personal and professional competence by enabling students to assess statistical methodologies used in biostatistics research studies.

PO7: Effective Citizenship and Ethics
CO6: Critical evaluation skills: The exercise of critical evaluation skills partially contributes to effective citizenship and ethics by assessing the credibility of statistical methodologies used in biostatistics research studies.

PO9: Self-directed and Life-long learning
All Cos: Each Course Objective necessitates continuous learning and skill development in utilizing statistical tools, aligning directly with the program outcome of self-directed and life-long learning.

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2022)
Academic Year 2022-2023

Class: M. Sc. I (Semester- I)
Paper Code: **PSMB113**
Paper: III
Title of Paper: Biochemistry
Credit: 4
No. of lectures: 60

Course Objective:

1. To apply basic principles of chemistry to biological systems and molecular biology
2. Know about the composition of living matter and importance of water and buffer in life
3. To provide students with a solid foundation in the fundamental principles of biochemistry, including the structure, function, and metabolism of biological molecules.
4. To introduce students to the techniques and methodologies used in biochemical research and analysis.
5. To explore the relationship between structure and function of biomolecules and their role in cellular processes.
6. To foster critical thinking and problem-solving skills in the context of biochemical processes and pathways.
7. To promote an awareness of the applications of biochemistry in various fields, such as medicine, biotechnology, and agriculture.

Course Outcome:

CO1.Demonstrate a comprehensive understanding of the structure, function, and properties of biomolecules, including proteins, carbohydrates, lipids, and nucleic acids.
CO2.Apply knowledge of biochemical principles to analyze and interpret experimental data related to biological molecules and processes.
CO3.Evaluate the applications of biochemistry in various fields, such as drug discovery, biotechnology, and genetic engineering.
CO4.Students will be able to demonstrate an understanding of fundamental biochemical principles.
CO5.Students will be able to develop in- depth understanding of the area of biochemistry to choose for the research purpose.
CO6.inculcate a healthy attitude to be a lifelong learner,

UNIT 1: Bioorganic Chemistry (15L)

- Covalent bonds – Glycosidic bond, Peptide bond, Phosphodiester bond
- Bonding other than covalent – H-bonds, Van der Waal's interaction, ionic bonding.
- Reactions of organic molecules: A brief overview of Important reactions in organic chemistry e.g., Substitution, Addition, Elimination, Rearrangement, Oxidation, Reduction, etc.
- Bioorganic mechanism of enzyme catalysed reactions: Acid – base, covalent catalysis and metal ion catalysis with examples of respective enzymes.
- Stereochemistry: Three-dimensional shape of molecules, conformation and configuration, structure and biological activity.

- Structure of water and ionization, Concept of pH of weak acids and weak bases, Henderson-Haselbech equation, concept of buffer, strength of buffer, buffer value, important biological buffers.

UNIT 2: Nucleic acid chemistry (15L)

- Structure of bases, nucleosides, nucleotides, phosphodiester linkages
- 5' phosphate, 3'hydroxyl polarity of nucleic acids
- Tautomeric forms of bases and their implication in pairing of bases
- Structure of DNA (A, B and Z forms)
- Tm value Cot curves
- Structure of tRNA, rRNA, and mRNA and other RNAs

UNIT 3: Protein Chemistry (15L)

- Physical and chemical properties of amino acids
- Classification of amino acids
- Amino acids as buffers
- Non-covalent interactions
- Conformational properties of proteins
- Polypeptide chain geometry
- Resonance forms of the peptide group
- *cis/trans* isomers of peptide group
- Ramachandran plot
- Secondary, Super-secondary, Motif & Domain
- Tertiary and Quaternary structures of proteins, (Myoglobin & Hemoglobin)

UNIT 4: Carbohydrate, lipid & vitamin biochemistry (15L)

a. Carbohydrate Chemistry:

- Structure and function of Mono, di, oligosaccharides and polysaccharides with examples
- asymmetric centre in sugars
- Dseries, L- series, dextro, leavo-rotatory
- reducing and non- reducing sugars
- sugar anomers
- sugar epimers
- sugar derivatives such as sugar alcohols, amino sugars, sugar acids, deoxy sugars
- Any two methods of estimation of carbohydrates

b. Lipid Chemistry:

Classification of lipids according to chemical structure, fatty acids, saturated, unsaturated, branched, nomenclature system, structure and function of triglycerides, phospholipids, sphingolipids, terpenes, prostaglandins, waxes, and steroids, any two methods of estimation and characterization of lipids

c. Vitamin Chemistry:

Fat soluble Vitamin – Type (A, D, E, K), Source, forms, function, deficiency, RDI (Recommended Daily Intake), Overdose

Text / Reference Books:

1. Clayden, Greeves, Warren and Wothers, *Organic Chemistry*, Oxford Press
2. Jerry March, *Advanced Organic Chemistry*, John Wiley

3. Voet Donald and Voet Judith G. (1995) *Biochemistry*, 2nd Ed.. John Wiley and sons, New York.
4. Conn Eric, Stumpf Paul K., Bruuening George, Doi Roy H., (1987) *Outlines of Biochemistry* 5th Ed, John Wiley and Sons, New Delhi.
5. Nelson D. L. and Cox M. M. (2002) *Lehninger's Principles of Biochemistry*, Mac Millan Worth Pub. Co. New Delhi
6. Segel Irvin H. (1997). *Biochemical Calculations*. 2nd Ed. John Wiley and Sons, New York.
7. Campbell M. K.(1999)Biochemistry. 3rd edition Harcourt Brace College Publishers
8. Garrett, R. H. and Grisham, C. M. (2004) *Biochemistry.* 3rd Ed. Brooks/Cole, Publishing Company, California.
9. David J Holme, Hazel Peck (1998) *Analytical Biochemistry,* 3rd Ed., Prentice Hall, Pearson Education Limited, Harlow England.
10. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006) *Biochemistry.* 6th Edition. Freeman, New York.
11. Garrett, R. H. and Grisham, C. M. (2004) *Biochemistry.* 3rd Ed. Brooks/ Cole, Publishing Company, California
12. Cotterill, R. M. J. (2002) *Biophysics: An Introduction.* John Wiley & Sons, England.

Mapping of Program Outcomes with Course Outcomes

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)									
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	2									
CO 2		2								
CO 3			3		2		2			
CO 4				2						
CO 5				2						
CO 6						2				2

Justification for the mapping

PO1.Disciplinary Knowledge:

CO1 demonstrates a comprehensive understanding of biomolecules, showcasing disciplinary knowledge in biochemistry.

PO2.Critical Thinking and Problem Solving:

CO2 involves applying knowledge of biochemical principles to analyze and interpret experimental data, reflecting critical thinking and problem-solving skills.

PO3.Social Competence:

While not explicitly mentioned in the provided sentences, the applications of biochemistry in drug discovery, biotechnology, and genetic engineering (CO3) can have social implications and may involve collaboration and communication skills.

PO4.Research-related Skill:

CO4 and CO5 involve demonstrating an understanding of fundamental biochemical principles and developing an in-depth understanding of biochemistry for research purposes, emphasizing research-related skills.

PO5.Transdisciplinary Knowledge:

CO3, which involves evaluating the applications of biochemistry in various fields, touches upon transdisciplinary knowledge as it connects biochemistry with other disciplines like drug discovery, biotechnology, and genetic engineering.

PO6.Personal and Professional Competence:

CO6 aims to instill a healthy attitude as a lifelong learner, reflecting personal and professional competence.

PO7.Effective Citizenship and Ethics:

Ethics is implicit in CO3 when evaluating the applications of biochemistry, especially in drug discovery and genetic engineering, and is aligned with effective citizenship and ethical considerations.

PO8.Environment and Sustainability:

The provided sentences do not explicitly address environmental aspects or sustainability.

PO9.Self-directed and Lifelong Learning:

CO6 explicitly mentions the goal of inculcating a healthy attitude to be a lifelong learner, emphasizing self-directed learning.

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2022)
Academic Year 2022-2023

Class: M. Sc. I (Semester- I)
Paper Code: **PSMB114**
Paper: IV
Title of Paper: Cell Biology
Credit: 4
No. of lectures: 60

Course objectives

1. Recognize and describe the structure and function of major cellular organelles.
2. Understand the processes of diffusion, osmosis, and active transport across the cell membrane.
3. Describe the phases of the cell cycle, including interphase, mitosis, and meiosis. and understand the significance and regulation of cell division.
4. Explain cellular communication and signaling pathways.
5. Explore the role of receptors, second messengers, and signal transduction.
6. Explore different cell types and their specialized functions. And understand the organization of cells into tissues and organs.
7. Understand the interdisciplinary nature of cell biology, connecting concepts with genetics, biochemistry, and physiology.

Course outcome

CO1. Student able to identify and describe the structure of eukaryotic and prokaryotic cells.
CO2. Student able to understand the functions of different cellular organelles.
CO3. Understand the cell cycle and its regulation.
CO4. Understand how cells respond to external signals and environmental cues.
CO5. Explore the diversity of cell types and their specialized functions in different tissues and organisms.
CO6. Apply knowledge to solve problems related to cellular processes and functions.
CO7. Understand how cell biology intersects with other fields, such as genetics, biochemistry, and physiology.

UNIT 1: Ultrastructure and Organization of Eukaryotic Cell (15L)

Structural organization and role of

- Cytoskeleton (Actin. Microtubule and Intermediate filament)
- Endoplasmic Reticulum
- Golgi apparatus
- Nucleus
- Mitochondria
- Chloroplast

Cell division

- Events in cell cycle
- Regulation of cell cycle
- Apoptosis and necrosis

UNIT 2: Intracellular Compartments and protein sorting (15L)

- Compartmentalization of cells

- Transport of molecules between the nucleus and cytosol, peroxisomes, Endoplasmic reticulum
- Transport of proteins into mitochondria and chloroplasts
- Intracellular vesicular traffic: Endocytosis, exocytosis, transport from the ER through the Golgi apparatus.

UNIT 3: Communication and Coordination among microorganisms (15L)

- Life cycle and Molecular mechanism of quorum sensing in *Dyctiostellium discoidum*,
- Life cycle and Molecular mechanism of quorum sensing in *Myxococcus xanthus*
- Quorum sensing in Gram positive (*Staphyllacoccus aureus*)
- Quorum sensing in Gram negative bacteria (*Vibrio Fischeri*)
- Biofilms their organization, signals involved in their formation and dispersal, applications of study on biofilms in pathogenic and non-pathogenic environments.

UNIT 4: Cell signalling in eukaryotic systems (15L)

- Introduction of cell signalling and, importance of cell signalling
- Mode of signalling- autocrine, paracrine, endocrine, juxtacrine signalling,
- Receptor: 1) Nuclear receptor,
  2) Cell surface receptor: Ion channel receptor
  G protein coupled receptor
  Enzyme coupled receptor

Text / Reference Books:

1. Alberts Bruce (1985) Molecular Biology of Cell.Garland Pub
2. Metzler David E. (2001) Biochemistry: The chemical Reactions of Living Cells, Volume 1&2, Academic Press California.
3. Harvey Lodish, Arnold Berk, S. Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell (2000) Molecular Cell Biology, 4th edition, W. H. Freeman & co., New York
4. Hamilton W. Allan, (1987) Biofilms: Microbial Interactions and Metabolic activities, in Ecology of Microbial Communities, (Eds. M. Fletcher, T. R. G. Gray and J. G. Jones) Cambridge University Press, Cambridge.
5. Petersm J. E. (1969) Isolation, cultivation and maintenance of Myxobacteria, Methods in Microbiology (Eds. Norris J. R. and W. Ribbons) Vol. 3B, Academic Press London, 185-210.
6. Toole 'O' George, H. B. Kaplan, R. Kolter,(2000) Biofilm formation as microbial development Annual Review of Microbiology, Vol. 54, 49-79
7. Melissa B. Miller and Bonnie L. Bassler (2001) Quorum sensing in bacteria. Annu. Rev. Microbiol. Vol. 55, 165–99.
8. Christopher M. Waters and Bonnie L. Bassler (2005) Quorum sensing:cell-to-cell communication in bacteria. Annu. Rev. Cell Dev. Biol. Vol. 21, 319–46
9. Nelson D. L. and Cox M. M. (2005) Lehninger's Principles of Biochemistry, Fourth edition, W. H. Freeman & Co. New York
10. Munehiko Asayama and Yasuo Kobayashi (1993) Signal transduction and sporulation in Bacillus subtilis: autophosphorylation of SpoOA, a sporulation initiation

Mapping of Program Outcomes with Course Outcomes

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)									
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	2	1			2					
CO 2	2	2	1	1	2	2	1	1	2	
CO 3										
CO 4										
CO 5										
CO 6										

Justification for the mapping

PO1:Disciplinary Knowledge:

CO 1: "Student able to identify and describe the structure of eukaryotic and prokaryotic cells."
CO2: This aligns with the concept of disciplinary knowledge as it involves understanding the structures and functions of cells, which is a fundamental aspect of biology.

PO2.Critical Thinking and Problem Solving:

CO1: Apply knowledge to solve problems related to cellular processes and functions."
CO2: Critical thinking and problem-solving are represented in the second set as essential skills, implying the ability to use knowledge in practical scenarios.

PO3.Social Competence:

CO2: Social competence is not explicitly addressed in the first set, which focuses more on cellular and biological concepts.

PO4.Research-Related Skill:

CO2: Research-related skills are not explicitly mentioned in the first set, but the application of knowledge to solve problems implies a practical and research-oriented approach.

PO5.Transdisciplinary Knowledge:

CO1 "Understand how cell biology intersects with other fields, such as genetics, biochemistry, and physiology."
CO2: Transdisciplinary knowledge is also represented in the second set as it emphasizes understanding the connections between cell biology and other disciplines.

PO6.Personal and Professional Competence:

CO2: This category in the second set is broader and encompasses a wide range of skills, including those related to personal and professional development, beyond the scope of cell biology.

PO7.Effective Citizenship and Ethics:

CO2: This category in the second set addresses aspects beyond the scope of cell biology, such as ethical considerations and effective citizenship.

PO8.Environment and Sustainability:

CO2: Environment and sustainability are not explicitly addressed in the first set but are included in the second set as essential considerations in a broader context.

PO9.Self-Directed and Lifelong Learning:

CO2 This category in the second set aligns with the idea of continuous learning and personal development, which goes beyond the specific knowledge of cell biology

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2022)
Academic Year 2022-2023

Class: M. Sc. I (Semester- I)
Paper Code: **PSMB115**
Paper: V
Title of Paper: Practical Course: Microbial Systematics
Credit: 4
No. of lectures: 60

Course Objectives:

1. To Enrich students' knowledge and train them in the pure microbial sciences.
2. To acquire in-depth knowledge of bacterial cell structure and organization, cultivation methods and growth patterns, and reproduction.
3. To expand the knowledge of bacterial diversity and its significance.
4. To analyze bacteria microscopically using various staining methods.
5. To explore students the enormous biological diversity in the microbial world.
6. To describe the fundamental concepts and terminology of taxonomic organization and parameters used in classifying bacteria.
7. To enhance the practical skills and identify given organism upto genus level using Bergey's manual.

Course Outcome:

CO1. Students will learn different isolation techniques used for isolation of organisms from their natural habitat.
CO2. Draws the student's attention to the Universe of Microbial diversity, with focused studies of the contributions that specific microorganism makes to the universe.
CO3. Students will train in Isolation of bacteria and characterize it upto genus level.
CO4. Students will train in isolation of extremophiles and characterize it upto genus level.
CO5. Students will train in isolating and characterizing different fungi.
CO6. Acquire basic skills in 16SrRNA gene sequence analysis using BLAST and preparation of phylogenetic tree.
CO7. It provides a practical guide to microbial diversity from phylogenetic perspective in which students learn evolutionary relationship.

UNIT 1: Isolation of bacteria from natural samples. (15L)

- Isolation of a Mesophilic bacteria
- Identification of a Mesophilic bacteria up to the Genus level using the Bergey's Manuals.
- Enrichment and isolation of Actinomycetes.
- Identification of a Actinomycete up to the Genus level using the Bergey's Manuals. (The identification key must be designed for each isolated and identified bacterium. Students are expected to isolate at least one Genus from each group).

UNIT 2: Isolation of fungi from natural samples. (15L)

- Enrichment and isolation of Molds (Saprophytic)
- Morphological Identification of the Mold.
- Enrichment and isolation of Yeast
- Morphological Identification of the Yeast.

(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).

UNIT 3: Isolation of extremophiles from natural samples. (15L)

- Enrichment and Isolation of a Halophilic bacteria
- Identification of a Halophilic bacteria up to the Genus level using the Bergey's Manuals.
- Enrichment and isolation of Thermophile.
- Identification of a Thermophile up to the Genus level using the Bergey's Manuals. (The identification key must be designed for each isolated and identified bacterium. Students are expected to isolate at least one Genus from each group).

UNIT 4: (15L)

- Enrichment and Isolation of any one type of cyanobacterium from a natural sample.
- Identification of cyanobacterium up to the genus level. (The identification key must be designed for each isolated and identified cyanobacterium. Students are expected to isolate at least one Genus of cyanobacteria).
- Study the microbial diversity of a natural sample using Simpson's index.
- 16SrRNA gene sequence analysis using BLAST and preparation of phylogenetic tree.

Text / Reference Books:

1. Breed and Buchanan. Bergey's Manual of Determinative Bacteriology. 8th Edition, 1974.
2. Breed and Buchanan. Bergey's Manual of Determinative Bacteriology. 9th Edition, 1982.
3. Breed and Buchanan. Bergey's Manual of Systematic Bacteriology. 2nd Edition, (Volumes. 1 – 5) (2001 – 2003).
4. Sykes, G. and F. A. Skinner (Eds). Actinomycetales: Characteristics and Practical Importance. Society for Applied Bacteriology Symposium Series No. 2, Academic Press. 1973.
5. Barnett, H. L. and Hunter, B. B. 1960. Illustrated Genera of Imperfect Fungi. Burgess Publishing Co., Minnesota.
6. Lodder J. (1974). The Yeasts: A Taxonomic Study, North Holland Publishing Co. Amsterdam.
7. Bergey's Manual of Systematic Bacteriology (2nd Edition) Volume One: The Archaea and the Deeply Branching and Phototrophic Bacteria.
8. Boone, David R.; Castenholz, Richard W. (Eds.). Originally published by Williams & Wilkins,

Mapping of course outcomes and programme outcomes:

Weightage: 1= weak or low relation, 2= Moderate or partial relation, 3= Strong or direct relation

	Programme Outcomes (POs)								
Course outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3		3			2		3
CO2	3	2	2		3	2	3	3	

CO3	3	3	3			3			2
CO4	3								
CO5	3				2				
CO6	3			3					3
CO7	3	2						3	

Justification for the mapping

PO1 **Disciplinary Knowledge:**

CO1: It introduce students to essential techniques in microbiology, specifically isolation methods.

CO2: It expands students' understanding of microbial diversity, emphasizing the ecological roles of microorganisms

CO3: Involves hands-on training in bacterial isolation and characterization, contributing to disciplinary knowledge in microbiology, particularly in taxonomy and classification.

CO4: Focuses on specialized isolation and characterization, contributing to disciplinary knowledge with an emphasis on extremophiles and their unique features..

CO5: Involves practical training in the isolation and characterization of fungi, contributing to disciplinary knowledge in mycology.

CO6: Introduces students to molecular techniques and analysis methods, contributing to disciplinary knowledge in molecular microbiology and phylogenetics.

CO7: Emphasizes the importance of understanding microbial diversity from an evolutionary perspective, contributing to disciplinary knowledge in microbial evolution and phylogeny

PO2 **Critical Thinking and Problem Solving:**

CO1: Involves critical thinking in choosing and applying appropriate isolation techniques based on the characteristics of the natural habitat

CO2: Encourages critical thinking by prompting students to consider the ecological contributions of specific microorganisms

CO3: Problem-solving skills may be involved by students in addressing ambiguities or unexpected results.

CO7: Emphasizes critical thinking in understanding microbial diversity from a phylogenetic perspective

PO3 **Social competence:**

CO2: Encourages discussions and sharing of ideas among students, fostering social competence through the exchange of perspectives and collaborative learning.

CO3: Involves practical training that may be conducted in a team, promoting social competence through collaboration in laboratory settings.

PO4 **Research-related skills and Scientific temper:**

CO1: Introduces students to fundamental skills in microbiological research by teaching isolation techniques. Scientific temper is fostered as students engage in systematic and evidence-based practices.

CO6: Introduces molecular techniques and analysis methods, developing advanced research-related skills. Scientific temper is nurtured through the use of evidence-based molecular analysis.

PO5 **Trans-disciplinary knowledge:**

CO2: Encourages students to consider the ecological contributions of

microorganisms, connecting microbiology to broader ecological and environmental contexts..

CO5: Practical training in fungal isolation connects to applications in mycology, agriculture, and environmental studies.

PO6 **Personal and professional competence:**

CO2: Encourages a broader perspective on the contributions of microorganisms, fostering an appreciation for the societal and professional relevance of microbiology.

CO3: Involves practical training in bacterial isolation, contributing to both personal growth and professional competence by acquiring specific skills in taxonomy and classification.

PO7 **Effective Citizenship and Ethics:**

CO1:Learning isolation techniques contributes to effective citizenship by emphasizing responsible and ethical practices in collecting and isolating microorganisms from their natural habitats.

CO2:Drawing attention to microbial diversity encourages effective citizenship by fostering awareness and understanding of the contributions of microorganisms, aligning with ethical considerations in appreciating the importance of microbial life.

PO8 **Environment and Sustainability:**

CO2: Encourages an understanding of the contributions of microorganisms to the universe, fostering an appreciation for the ecological roles of microorganisms and their impact on environmental sustainability..

CO7: Understanding microbial diversity from a phylogenetic perspective may involve discussions on the evolutionary adaptation of microorganisms to changing environments, connecting to sustainability considerations

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2022)
Academic Year 2022-2023

Class: M. Sc. I (Semester- I)
Paper Code: **PSMB116**
Paper: VI
Title of Paper: Practical Course: Cell biology and Biochemistry
Credit: 4
No. of lectures: 60

Course Objectives:

1. Demonstrate proficiency in using common laboratory techniques for the quantitative analysis of biomolecules, including spectrophotometry, chromatography, and electrophoresis.
2. Perform protein estimation using methods such as the Bradford assay, Lowry assay, or BCA assay.
3. Understand the principles behind protein estimation techniques and factors influencing accuracy.
4. Construct standard curves for biomolecule quantification to convert experimental data into meaningful concentrations.
5. Emphasize the importance of precision and accuracy in biomolecule estimation.
6. Perform quality control measures to ensure reliable and reproducible results.

Course Outcome:

CO1. Understand and apply ethical considerations related to the use of biomolecules in research and analysis
CO2. Differentiate between various chromatographic techniques and their applications.
CO3. Proficiency in TLC Techniques:
CO4. Understand the selection of appropriate stationary and mobile phases for biomolecule separation.
CO5. Apply appropriate methods for estimating the concentration of specific biomolecules in a given sample.
CO6. Understand the validation processes for biomolecule estimation methods.

UNIT 1: Good laboratory practices and cell biology (15L)

- Good laboratory practices: 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 (pH meter, spectrophotometer).
- preparing/designing SOP for the instrument.
- Isolation and detection of bacterial pigment
- Studying the stages of mitosis in growing tip of onion root cells

UNIT 2 and 3: Biochemistry (30L)

- Estimation of reducing sugar by DNSA method from a natural sample
- Estimation of total carbohydrate by Phenol sulphuric acid method from the natural sample
- Estimation of protein from a natural sample by Lowry method

- Estimation of protein from a natural sample by Bradford method
- Estimation of protein from a natural sample by UV Spectrophotometry
- Separation of sugar from a natural sample by two-dimensional paper Chromatography
- Separation of amino acids from a natural sample by thin layer Chromatography
- Determination of pKa of a monoprotic weak organic acid
- Preparation of phosphate and acetate buffer.

UNIT 4: Computer application and statistical analysis of data (15L)

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

Text / Reference Books:

1. Alberts Bruce (1985) *Molecular Biology of Cell.*Garland Pub
2. Metzler David E. (2001) *Biochemistry: The chemical Reactions of Living Cells*, Volume 1&2, Academic Press California.
3. Harvey Lodish, Arnold Berk, S. Lawrence Zipursky, Paul Matsudaira, David Baltimore, and
4. James Darnell (2000) Molecular Cell Biology, 4th edition, W. H. Freeman & co., New York
5. Nelson D. L. and Cox M. M. (2005) Lehninger's Principles of Biochemistry, Fourth edition, W. H. Freeman & Co. New York.

Mapping of Program Outcomes with Course Outcomes

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)									
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	2						1			
CO 2		2								
CO 3			1							
CO 4				3						
CO 5					2					
CO 6						2			2	

Justification for the mapping

PO1: Disciplinary Knowledge:

CO1:falls under disciplinary knowledge as it requires a deep understanding of the ethical principles and guidelines specific to the field of bimolecular research.

PO2: Critical Thinking and Problem Solving:

CO2: involves critical thinking and problem-solving skills. It requires the ability to analyze different techniques and determine their suitability for specific research objectives.

PO3. Social Competence:
CO:3Proficiency in TLC techniques (CO3) may involve social competence as it could be applied in collaborative research settings where effective communication and teamwork are essential for successful implementation.

PO4. Research-Related Skill:
CO4: Understanding the selection of appropriate stationary and mobile phases for biomolecule separation (CO4) is a research-related skill. It involves the application of knowledge to make informed decisions in the design and execution of experiments.

PO5.Transdisciplinary Knowledge:
CO5: Applying appropriate methods for estimating the concentration of specific biomolecules in a given sample (CO5) may require transdisciplinary knowledge, as it involves integrating techniques and methods from various scientific disciplines to achieve accurate results.

PO6.Personal and Professional Competence:
CO6: Understanding the validation processes for biomolecule estimation methods (CO6) contributes to personal and professional competence. It involves ensuring the accuracy and reliability of data, which is crucial for professional credibility.

PO7.Effective Citizenship and Ethics:
CO1: Understanding and applying ethical considerations (CO1) directly align with effective citizenship and ethics. It involves a commitment to responsible and ethical conduct in the use of biomolecules in research.

PO8.Environment and Sustainability:
While not explicitly stated, biomolecular research often has implications for the environment and sustainability, especially if it involves the use of resources or materials with environmental impact.

PO9.Self-Directed and Lifelong Learning:
CO6: The entire set of learning outcomes emphasizes the need for continuous learning. This is particularly evident in understanding validation processes (CO6) as it requires staying current with evolving methodologies and standards in biomolecular research