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**
	CCPSMB121	**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		**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 I	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		**4**
	PSMB245	Dissertation I	**4**
	PSMB246	Dissertation II	**4**
	SD II	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

Learning Objectives:

- To introduce the concept of Bacterial taxonomy
- To expand the knowledge of unculturable bacteria
- To introduce the various bioinformatics tools to study the concept of sequencing
- To help student's build-up a progressive and successful career

Learning Outcome:

- Acquire basic skills on bioinformatics tools to study the taxonomy
- Introduce the concepts of application and research in Microbiology

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

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Class: M. Sc. I (Semester- I)

Paper Code: **PSMB112**

Paper: II

Title of Paper: Quantitative Biology

Credit: 4

No. of lectures: 60

Learning Objectives:

- To introduce the concept and application of statistics.
- To understand the probability and laws of probability.
- To understand inferential statistics.

Learning Outcome:

- Students should be able to apply descriptive and inferential statistics on the data collected during research work.
- Students should be able to organise and represent the collected data appropriately.

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

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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

Learning Objectives:

- To apply basic principles of chemistry to biological systems and molecular biology
- Know about the composition of living matter and importance of water and buffer in life

Learning Outcome:

- Students will be able to demonstrate an understanding of fundamental biochemical principles, metabolic pathways and the regulation of biochemical processes.
- Students will be able to develop in- depth understanding of the area of biochemistry to choose for the research purpose.

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.

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

Learning Objectives:

- To provide an overview of the current concepts of cell signalling,
- To understand the experimental design leading to their formulation.
- To enrich students' knowledge and train them in the pure microbial sciences

Learning Outcome:

- Use and apply those facts, concepts, and principles appropriately, even in situations that you have not previously encountered.
- Interpret and evaluate evidence for hypotheses about cell structure and function.
- Devise strategies to address unsolved issues in cell biology.

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

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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

Learning Objectives:

- To Enrich students' knowledge and train them in the pure microbial sciences
- To enhance the practical skills and identify given organism upto genus level using Bergey's manual.

Learning Outcome:

- Students will learn different isolation techniques used for isolation of organisms from their natural habitat.
- Students will train in isolating and characterizing different extremophiles.

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,

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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

Learning Objectives:

- To develop quantitative skills of estimation of biomolecules
- To apply chromatographic techniques and approach of analysis.

Learning Outcome:

- Students should be able to apply basic principles of chemistry to biological system.
- Student should be able to execute quantitative analysis and statistics to interpret biochemical data.

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.

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Class: M. Sc. I (Semester- II)
Paper Code: **PSMB121**
Paper: I
Title of Paper: Virology
Credit: 4
No. of lectures: 60

Learning Objectives:

- To enrich students' knowledge about basic chemistry belongs to microbiology
- To describe and review the elements of the viral life cycle
- Explain vaccine strategies and mechanism of antiviral drug
- To help student's build-up a progressive and successful career

Learning Outcome:

- Student will understand principles of virus pathogenesis.
- Students will understand viral replication strategies and compare replication mechanism used by viruses.

UNIT 1: Structure and Replication of viruses (15L)

- Enveloped and non-enveloped viruses
- Capsid symmetries – Icosahedral, Helical, Simple and Complex Capsid
- Structural components of virus – Protein – Envelope proteins (Glycoprotein), Matrix proteins and Lipoproteins, Genome – dsDNA, ssDNA, dsRNA, ssRNA (positive sense, negative sense and ambisense), linear, circular, segmented
- Virus related structures – Viroids and Prions

Replication of viruses

- Mechanism of virus attachment
- Entry into host cell
- Uncoating of viral genome
- Transcription stratergies for RNA genome & DNA genome
- Genome replication - RNA replication, DNA replication
- Reverse Transcription
- Post transcriptional processing
- Translation of viral proteins
- Protein nucleic acid interactions and genome packaging
- Assembly, exit and maturation of progeny virions

UNIT 2: Cultivation and Detection methods for viruses (15L)

Cultivation of viruses

- *In ovo*: using embryonated chicken eggs
- *In vivo*: using experimental animals
- *Ex vivo / In vitro:* using various cell cultures – primary and secondary cell lines, suspension cell cultures and monolayer cell culture

Diagnostic and detection methods for viruses:

- Direct methods of detection – Light microscopy (inclusion bodies), Electron microscopy and Fluorescence microscopy
- Immnuodiagnosis, Hemagglutination and Hemagglutination inhibition tests, Complement fixation, Neutralization, Western blot, Radioactive Immuno Precipitation Assay (RIPA), Flow Cytometry and Immunohistochemistry
- Nucleic acid based diagnosis: Nucleic acid hybridization, Polymerase Chain Reaction (PCR), Microarray and Nucleotide sequencing, LINE probe assay

Infectivity assay for animal and bacterial viruses

- Plaque method
- Pock counting
- End point methods, LD50, ID50, EID50, TCID50.

Infectivity assays of plant viruses.

UNIT 3: Bacteriophages (15L)

Bacteriophage ecology

Morphology, Genome organization and Life cycles of

- T phages (odd and even)
- Lambda phage
- M13 phage
- Phi X 174 phage

Bacteriophage therapy for control of any two bacterial diseases

UNIT 4: Viral Therapeutics (15L)

Vaccines:

- Conventional vaccines: Killed and attenuated
- Modern vaccines: Concepts and examples (DNA vaccines, Recombinant DNA, Recombinant protein vaccines, Subunit vaccines, Peptide vaccines, Anti-idiotype vaccines, Edible vaccines, mRNA vaccine, Vaccine formulations and delivery: Adjuvants, immunomodulators, cytokines)

Antiviral agents:

- Designing and screening
- Mechanism of action (e.g., Nucleoside analogues, Nucleotide analogues, Antisense, Topical immune modulator, neuraminidase inhibitors, Ion channel function inhibitors of M2 proteins, Pyrimidines)

Antiretroviral agents (any two):

- Mechanism of action
- Mechanism of resistance
- Modern approaches of virus control - Small interfering RNA (siRNA), Ribozymes

Text / Reference Books:

1. Cann A.J, (2005), Principles of Molecular Virology, 4th Ed. Elsevier Academic Press.
2. Dimmock N. J., Easton A. J. and K. N. Leppard, (2007), Introduction to Modern Virology, 6th Ed. Blackwell Publishing.
3. Edward K. Wagner, Martinez J. Hewlett, (2004), *Basic Virology*, Blackwell Publishing
4. Flint S. J., V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka, (2003),
5. *Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses*, American Society Microbiology.

6. Haaheim L. R., J. R. Pattison and R. J. Whitley, (2002), *A Practical Guide to Clinical Virology. 2nd Ed.* Edited by, John Wiley & Sons, Ltd.
7. Knipe David M., Peter M. Howley, Diane E. Griffin, Robert A. Lamb, Malcolm A. Martin, Bernard Roizman, Stephen E. Straus, (2007), *Field's Virology,* 5th Ed. Lippincott Williams & Wilkins
8. Luria S. E. et.al. (1978) *General virology*, 3rd Ed, New York. John Wiley and Sons.
9. Straus J. H. and Straus E.S. (1998) *Evolution of RNA Viruses* Ann. Rev. Microbiol. 42: 657 – 83
10. Mahy B. WJ. And Kangro H.O., (1996), Virology Methods Manual, Academic Press.
11. Shors T. (2011), Understanding Viruses, 2nd Ed., Jones & Bartlett Publishers LLC, Canada.
12. Stephenson J. R. and Warnes A., (1998), Diagnostic Virology Protocols: Methods in Molecular Medicine, Humana Press.
13. Wiedbrauk D. L. and Farkas D.H., (1995) Molecular Methods For Virus Detectin, Academic Press.
14. Calendar R. and Abedon S. T. (2006), The Bacteriophages, 2nd Ed. Oxford University Press.
15. Douglas John, (1975), *Bacteriophages*, Chapman and Hall, London.
16. Guttman Burton S. and Elizabeth M. Kutter, (2002), *Bacteriophage Genetics*,
17. Uldis N. Streips and Ronald E. Yasbin, Editors, Modern Microbial Genetics, 2nd Ed., Wiley- Liss Inc. 26 Colmon M. P. (2009) New New antivirals and drug resistance, Annual Review of Biochemistry, 78, 95 – 118.

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(w. e. from June, 2022)
Academic Year 2022-2023

Class: M. Sc. I (Semester- II)
Paper Code: **PSMB122**
Paper: II
Title of Paper: Instrumentation
Credit: 4
No. of lectures: 60

Learning Objectives:

- To enrich students' knowledge and train them in the instrumentation
- To allow students to understand about various separation and analytical techniques.

Learning Outcome:

- The student should be able to apply the knowledge regarding various separation techniques while purifying a biomolecule.
- The student should be able to apply the knowledge regarding various analytical techniques while analysing purified biomolecule.

UNIT 1: Chromatography (15L)

Partition Coefficient, Selectivity, Resolution, Column Efficiency, Van Deemter equation, Interpretation of chromatograms

Principle, components of instrument, operation and application of:

- Gel filtration chromatography
- Ion-exchange Chromatography
- Affinity chromatography
- Gas chromatography
- High Performance Liquid Chromatography

UNIT 2 Spectroscopy (15L)

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

- UV/Visible spectroscopy- Instrumentation, Molar Absorptivities, Beer and Lamberts Law.
- Fluorescence spectroscopy- Instrumentation, Quantum Yield, Quenching, FRET, Binding and Folding studies
- Infrared spectroscopy- Principle, Instrumentation, Absorption bands, FTIR and its advantages
- Atomic spectroscopy - Principle, Instrumentation and its application

UNIT 3: Electrophoresis and Centrifugation (15L)

- Electrophoresis – AGE, NATIVE PAGE, SDS-PAGE, Isoelectric focusing.
- Ultra-centrifugation, Differential centrifugation, Isopycnic and Rate zonal centrifugation

UNIT 4: Industrial Biosafety and Environment Regulation (15L)

- Laminar air flow
- Biosafety cabinet
- HVAC system

Text / Reference Books:

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, Agnieszka Kraj (2009) *Mass spectrometry: instrumentation, interpretation, and applications*, John Wiley & Sons, Inc.,Canada.
8. Irwin H. Segel (1976) *Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry,* 2nd Edition. John Wiley & Sons.
9. 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.

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Class: M. Sc. I (Semester- II)
Paper Code: **PSMB123**
Paper: III
Title of Paper: Metabolism
Credit: 4
No. of lectures: 60

Learning Objectives:

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

Learning Outcome:

- Enrich students' knowledge and train them in the pure microbial sciences
- Introduce the concepts of application and research in Microbiology

UNIT 1: Photosynthesis (15L)

- Structure of chloroplast
- electron carriers in photosynthesis
- photolysis of water
- light and dark reaction
- Hill reaction
- C3
- C4
- CAM plants
- energy consideration in photosynthesis
- Photorespiration
- Regulation of photosynthesis
- Comparison of Bacterial and plant photosynthesis

UNIT 2: Nitrogen metabolism (15L)

- Biochemistry of biological nitrogen fixation
- Properties of nitrogenase and its regulation
- Ammonia assimilation with respect to glutamine synthetase, glutamate dehydrogenase, glutamate synthetase, their properties and regulation
- Biosynthesis of five families of amino acids and histidine

UNIT 3: Anaerobic respiration (15L)

- Concept of anaerobic respiration
- Concept of Assimilation and Dissimilative metabolism
- Components of electron transfer system and energy generation of bacteria where nitrate, sulfate and CO_2 act as terminal electron acceptors
- Mechanism of oxygen toxicity.

UNIT 4: Enzyme Kinetics (15L)

- Importance of enzyme kinetics
- King Altman approach to derive – two substrate enzyme catalyzed reactions
- Types of two substrate enzyme catalyzed reactions
- Concept of allosterism, positive and negative co-operativity
- Models of allosteric enzymes (Monod, Wyamann and Changuax model, Koshland, Nemethy and Filmer model)
- kinetics of allosteric enzyme
- Hill plot
- Examples of allosteric enzymes and their significance in allosteric regulation

Text / Reference Books:

1. Nelson D. L. and Cox M. M. (2005) *Lehninger's Principles of Biochemistry*, Fourth edition, W. H. Freeman & Co. New York
2. Hall D. D. and Rao K. K. (1996) *Photosynthesis* 5th Ed.,Cambridge University Press
3. Michael T. Madigan, John M. Martinko, David A. Stahl, David P. Clark (2012) *Brock Biology of Microorganisms*, Thirteenth edition, Benjamin Cummings, San Francisco.
4. White David (2000) *Physiology and Biochemistry of Prokaryotes.* 2nd Ed. Oxford University Press, New York.
5. Mandelstam Joel and McQuillen Kenneth (1976) *Biochemistry of Bacterial Growth*, Blackwell Scientific Publication London.
6. Moat Albert G. and Foster John W. (1988) *Microbial Physiology* 2nd Ed. John Wiley and Sons New York.
7. Palmer Trevor (2001) *Enzymes: Biochemistry, Biotechnology and Clinical chemistry*, Horwood Pub. Co. Chinchester, England.
8. Segel Irvin H. (1997) *Biochemical Calculations* 2nd Ed., John Wiley and Sons, New York.

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Class: M. Sc. I (Semester- II)

Paper Code: **PSMB124**

Paper: IV
Title of Paper: Evolution and Ecology
Credit: 4
No. of lectures: 60

Learning Objectives:

- To gain an understanding of complex processes in population and community ecology
- To understand population growth and dynamics and its regulation
- Recognise and justify the importance of ecological interactions in shaping the structure of ecological communities

Learning Outcome:

- Students will be equipped to understand the evolutionary background and its importance.
- Students will acquire a theoretical understanding of population and community ecology to apply in the current issues in ecology.

UNIT 1: Evolution (15L)

- History and development of evolutionary theories.
  Inheritance of acquired characters (Lamarkism)
  Theory of Natural Selection. (Darwinism)
  Neo-Darwinism
- Evidences of evolution
- Pattern of Evolution
- Spontaneous mutation controversy, evolution of rates of mutation.
- Neutral evolution and molecular clocks,
- phylogeny and molecular distances
- Co-evolution. co-evolution of prey-predator interactions – Red Queen hypothesis
- Molecular evolution
- evolutionary stability of cooperation, sociality and multicellularity in microorganisms

UNIT 2: Species and speciation (15L)

- Concept of species and speciation
- Types of species
- Types of interactions,
  interspecific competition, herbivory, carnivory,pollination, symbiosis.
  Intra-specific competition: Competition exclusion principle and Hutchinson's rule.
- Types of speciation
- Speciation in sexual and asexual organisms
- Genetic drift: theory of genetic drift, Founder Effect and Bottleneck phenomenon
- Game Theory

UNIT 3: Ecology and Ecosystem (15L)
Concept of habitat and niche; Niche width and Niche overlap; Fundamental and Realized niche; Resource partitioning; Character displacement.

The Ecosystem

- Concept of ecosystem
- Trophic structure of ecosystem
- Types of ecosystems
- Ecosystem function
- Energy flow in Ecosystem
- Control in Ecosystem Function: Bottom up and Top-down control
- Ecological pyramids
- Ecological succession: Types; mechanisms; changes involved in succession; concept ofclimax.

UNIT 4: Population Ecology and Community Ecology (15L)

- Introduction to population ecology,
- Characteristic of Population
- Types and levels of selection; R and K selection.
- Population genetics, Hardy Weinberg's law
- Population growth curves: exponential and logistic
- Community Ecology:
  Nature of communities; community structure and attributes; levels of species diversity and its measurement; Edges and ecotones

Text / Reference Books:

1. Anders Gorm Pedersen, Molecular Evolution: Lecture Notes,February 2005.
2. Lindell Bromham and David Penny (2003). The Modern MolecularClock.www.nature.com/reviews/genetics. MARCH 2003 | VOLUME 4, **Page. 216.** Nature Publishing Group.
3. Lively Curtis, M. (1996). Host-parasite coevolution and sex. Bioscience **46**, 2, 107.
4. Leo C. Vining (1992). Roles of secondary metabolites from microbes.Edited by Derek J.Chadwick, Julie. Whelm Copyright.
5. Macan, T. T. (1974). Freshwater Ecology. Longman Group Ltd., London,
6. Meadows, P. S. and J. I. Campbell. (1978). An introduction to Marine Science. Blackie &Son Ltd., Glasgow.
7. Richards, B.N. (1987). Microbiology of Terrestrial Ecosystems. Longman Scientific &Technical, New York.

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Class: M. Sc. I (Semester- II)
Paper Code: **PSMB125**
Paper: V
Title of Paper: Practical Course: Biophysics & Virology
Credit: 4
No. of lectures: 60

Learning Objectives:

- To study life cycle of virus on particular host.
- To learn the technique of chromatographic separation of a mixture biomolecule

Learning Outcome:

- Students will learn process of gel filtration chromatography
- Students will learn and practice different methods used for isolation of viruses

UNIT 1: Virology (15L)

- Qualitative and quantitative detection of bacteriophage
- Animal virus titration by Hemagglutination inhibition test
- To study the One step growth curve of Bacteriophage.
- Demonstration of Egg inoculation technique for virus cultivation by various routes.

UNIT 2: Biophysics (15L)

- Biological synthesis of nanoparticles (actinomycetes /fungi /yeast) and their characterization by UV-Visible spectroscopy.
- Calibration of analytical instruments – Colorimeter and Spectrophotometer by estimation of biomolecules and Statistical analysis of data generated.
- Determination of molar extinction coefficient of biological molecule.

UNIT 3 and 4: Separation of Biomolecules (30L)

- To determine the ion-exchange capacity and nature of given resin using anion exchange
- chromatography.
- Protein electrophoresis by Native PAGE
- Protein electrophoresis by SDS PAGE
- Agarose Gel Electrophoresis
- Gel filtration chromatography

Text / Reference Books:

1. Nelson D. L. and Cox M. M. (2005) *Lehninger's Principles of Biochemistry*, Fourth edition, W. H. Freeman & Co. New York
2. Wilson Keith and Walker John (2005) *Principles and Techniques of Biochemistry and Molecular Biology*, 6th Ed. Cambridge University Press, New York.
3. Palmer Trevor (2001) *Enzymes: Biochemistry, Biotechnology and Clinical chemistry*, Horwood Pub. Co. Chinchester, England.
4. Segel Irvin H. (1997) *Biochemical Calculations* 2nd Ed., John Wiley and Sons, New York

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Class: M. Sc. I (Semester- II)

Paper Code: **PSMB126**

Paper: VI

Title of Paper: Practical Course: Enzymology & Microbial Metabolism

Credit: 4

No. of lectures: 60

Learning Objectives:

- To Isolate and characterize various enzyme degraders from natural samples.
- To obtain greatest possible yield of enzyme with highest catalytic activity and greatest yield.

Learning Outcome:

- Students will able to Understand kinetics of enzymes
- Students will learn to isolate Nitrogen fixers and detect secondary metabolites produced by them

UNIT 1: Purification and kinetics of enzyme (15L)

- Purification of extracellular enzyme (amylase from natural sample) by ammonium sulfate precipitation, and Dialysis.
- Construction of enzyme purification chart
- Determination of Km and Vmax values of any hydrolytic enzyme

UNIT 2: Plant Growth Promoting Rhizobacteria (15L)

- Enrichment, Isolation and characterization of (as nitrogen fixers) *Azospirillum*
- Detection of IAA produced by *Azospirillum*
- Detection of siderophore produced by *Azospirillum* or *Pseudomonas* (PGPR)
- Isolation and characterization of phosphate solublizing bacteria from rhizosphere soil

UNIT 3: Isolation and Characterization of Enzymatic degraders from soil (15L)

- Isolation and characterization of chitin degrading microbe
- Isolation and characterization of cellulose degrading microbe
- Isolation and characterization of pesticide degrading microbe

UNIT 4: Isolation and Characterization of Mycotoxin producing organism (15L)

- Isolation of Aflatoxin producing organism
- Identification of Aflatoxin producing organism
- Extraction of Aflatoxin from food /culture
- Detection of Aflatoxin in food /culture

Text / Reference Books:

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

2. Wilson Keith and Walker John (2005) *Principles and Techniques of Biochemistry and Molecular Biology*, 6th Ed. Cambridge University Press, New York.
3. Palmer Trevor (2001) *Enzymes: Biochemistry, Biotechnology and Clinical chemistry*, Horwood Pub. Co. Chinchester, England.
4. Segel Irvin H. (1997) *Biochemical Calculations* 2nd Ed., John Wiley and Sons, New York

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Class: M. Sc. I (Semester- II)

Paper Code:

Paper:

Title of Paper: **Certificate Course in Research Methodology**

Credit: 2

No. of lectures: 30

Learning Objectives:

- To introduce the concepts of application and research in Microbiology
- To inculcate sense of scientific responsibilities

Learning Outcome:

- Students will able to Understand philosophy and ethics of research
- Students should be able to write research proposal.

UNIT 1: Introduction to Research (15L)

- Philosophical foundation of research
- Understanding research publications
- Online Referencing Tools
- Plagiarism
- Statistical Software (R software)

UNIT 2: Scientific writing (15L)

- Construction of title and Preparation of abstract for a research paper/ proposed project
- Writing of materials and methods, results, discussion, conclusion etc
- Writing of research proposals
- Writing a project report