Anekant Education Society's

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

(Autonomous Institute)

Syllabus (CBCS) for M.Sc. Microbiology

w.e.f. June 2019

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 less 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 pathogenecity
- 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 university / 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. Microbiology curricula are operated at two levels viz. undergraduate and postgraduate. The undergraduate curricula are prepared to impart basic knowledge of the respective subject from all possible angles. In addition, students are to be trained to apply this knowledge particularly in day-today applications of Microbiology and to get a glimpse of research.

Objectives to be achieved:

- To enrich students' knowledge and train them in the pure microbial sciences
- To introduce the concepts of 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

Eligibility

B. Sc. with Principle subject Microbiology. The concerned centers may conduct their own entrance examination, for admission.

Duration of Course – Two years.

External students – There shall be no external students.

Course Structure –

There shall be four semesters, at each semester there will be 4 theory courses and 2 practical courses. In each theory course there shall be 4 core / compulsory credits. Each practical course shall have 4 core / compulsory credit.

Workload:

There shall be 16 contact hours per credit (1 hour / credit / week), out of which classroom teaching hours will be 12 and 4 contact hours for preparation of in-semester continuous assessment.

Anekant Education Society's
Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati

Autonomous

Course Structure for M.Sc. - I: Microbiology

Semester	Paper Code	Title of Paper	No. of Credits
I	MICRO4101	Microbial Systematics and Diversity	4
	MICRO4102	Quantitative Biology	4
	MICRO4103	Biochemistry	4
	MICRO4104	Cell Biology	4
	MICRO4105	Practical Course: Microbial Systematics	4
	MICRO4106	Practical Course: Cell biology and Biochemistry	4
	MICRO4107	Skill Development: Spectroscopic Techniques	2
II	MICRO4201	Virology	4
	MICRO4202	Instrumentation	4
	MICRO4203	Metabolism	4
	MICRO4204	Evolution and Ecology	4
	MICRO4205	Practical Course: Biophysics & Virology	4
	MICRO4206	Practical Course: Enzymology & Microbial Metabolism	4
	MICRO4207	Skill Development: Chromatographic Techniques	2

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2019)
Academic Year 2019-2020

Class : M. Sc. I (Semester- I)
Paper Code : MICRO4101
Paper : I
Title of Paper : Microbial Systematics and Diversity
Credit : 4
No. of lectures : 60

- **Learning Objectives:**
  - ✓ To enrich students' knowledge and train them in the pure microbial sciences
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  - ✓ 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: 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' bacterial 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: Concept of speciation and species evolution (15L)
- Differences in concept of 'species' in eukaryotes and prokaryotes.
- Definition of species in prokaryotes.
- Types of 'species'

- Evolution of species and concepts of speciation (in sexual and asexual organisms)
- Types of evolution (neutral, co-evolution);
- Types and levels of selection; r and k selection;
- molecular clocks; phylogeny and molecular distances

Text / Reference Books:

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

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Class : M. Sc. I (Semester- I)
Paper Code : MICRO4102
Paper : II
Title of Paper : Quantitative Biology
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

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

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, survival 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, 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 χ^2 (chi square) test - test for goodness of fit, independence and homogeneity; Non-parametric tests (Run test, Sign test, Wilcoxon's signed rank test, Mann- Whitney test).

Text / Reference Books:

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

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Class : M. Sc. I (Semester- I)
Paper Code : MICRO4103
Paper : III
Title of Paper : Biochemistry
Credit : 4
No. of lectures : 60

- **Learning Objectives:**
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UNIT 1: Bioorganic Chemistry (15L)

- Chemical reactivity: Concept and factors affecting reactivity (Inductive effect, Resonance / Mesomeric effect, Conjugation and Hyper-conjugation, Tautomerism, etc.)
- Bonding other than covalent – H-bonds, Van der Wall's interaction, charge transfer complexes, ionic bonding, Iondipole, Host-guest interactions
- 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 catalyzed 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
- Concept of pH of weak acids and weak bases, Henderson-Hasselbalch 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 t- RNA, r-RNA, and m-RNA 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 and lipid biochemistry (15L)

a. Carbohydrate Chemistry:

Mono, di, oligosaccharides and polysaccharides, with examples, asymmetric centre in sugars, D-series, 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, 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, methods of estimation and characterization of lipids

Text / Reference Books:

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

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Academic Year 2019-2020

Class : M. Sc. I (Semester- I)
Paper Code : MICRO4104
Paper : IV
Title of Paper : Cell Biology
Credit : 4
No. of lectures : 60

- **Learning Objectives:**
  - ✓ To enrich students' knowledge and train them in the pure microbial sciences
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- **Learning Outcome:**
  Enrich students' knowledge and train them in the pure microbial sciences
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UNIT 1: Ultrastructure and Organization of Eukaryotic Cell (30L)
Structural organization of: Cytoskeleton, Endoplasmic Reticulum, Golgi apparatus, Nucleus, Mitochondria, Chloroplast, Protein trafficking among various cellular compartments; Events in cell cycle, Regulation of cell cycle, apoptosis.

UNIT 2: Communication And Coordination among microorganisms (15L)
Life cycle of *Dyctiostellium discoidum*, Molecular mechanism of quorum sensing in slime moulds, Life cycle of myxobacteria, Molecular mechanism of quorum sensing in myxobacteria.
Quorum sensing in Gram positive and Gram negative bacteria, Biofilms, their organization, signals involved in their formation and dispersal, applications of study on biofilms in pathogenic and non-pathogenic environments

UNIT 3: Cell signaling in prokaryotic and eukaryotic systems (15L)
Secretory systems in bacteria, competence development, sporulation
Signaling in eukaryotes: autocrine, paracrine, endocrine, neurotransmitters
Pathways in cell signaling: GPCRs a)ion channels b) rhodopsin c) adenylate cyclase pathway d) regulation of cytosolic Ca2+

Text / Reference Books:

- Alberts Bruce (1985) *Molecular Biology of Cell.*Garland Pub
- Metzler David E. (2001) *Biochemistry: The chemical Reactions of Living Cells*, Volume 1&2, Academic Press California.
- 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
- 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.
- 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.
- Toole 'O' George, H. B. Kaplan, R. Kolter,(2000) *Biofilm formation as microbial development* Annual Review of Microbiology, Vol. 54, 49-79
- Melissa B. Miller and Bonnie L. Bassler (2001) *Quorum sensing in bacteria***.** Annu. Rev. Microbiol. Vol. 55, 165–99.
- 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.
- Nelson D. L. and Cox M. M. (2005) Lehninger's Principles of Biochemistry, Fourth edition, W. H. Freeman & Co. New York.
- Munehiko Asayama and Yasuo Kobayashi (1993) Signal transduction and sporulation in Bacillus subtilis: autophosphorylation of SpoOA, a sporulation initiation

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2019)
Academic Year 2019-2020

Class : M. Sc. I (Semester- I)
Paper Code : MICRO4105
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 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

A. Isolation of the following types of bacteria from natural samples. Identification of the bacteria to at least the Genus level using the Bergey's Manuals:
   Mesophilic bacteria
   Actinomycetes
   The identification key must be designed for each isolated and identified bacterium. Students are expected to isolate at least one Genus from each group.
B. Isolation of the following types of fungi from natural samples.
   Morphological Identification of the fungi.
   Molds (Saprophytic)
   Yeasts
   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.
C. Isolation and identification of any one type of cyanobacterium from a natural sample.
   The identification key must be designed for each isolated and identified cyanobacterium. Students are expected to isolate at least one Genus of cyanobacteria.
D. Isolation of the following types of bacteria from natural samples. Identification of the bacteria to at least the Genus level using the Bergey's Manuals:
   Halophilic bacteria
   Acidophilic Bacteria
   Thermophiles
   The identification key must be designed for each isolated and identified bacterium. Students are expected to isolate at least one Genus from each group.

Text / Reference Books:

- Breed and Buchanan. Bergey's Manual of Determinative Bacteriology. 8th Edition,

1974.

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

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Academic Year 2019-2020

Class : M. Sc. I (Semester- I)
Paper Code : MICRO4106
Paper : VI
Title of Paper : Practical Course: Cell biology and Biochemistry
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

A. 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, preparing / designing SOP for the same, maintenance of instruments
B. Buffer: Determination of pKa of a monoprotic weak organic acid; Preparation of buffers using KH_2PO_4 and K_2HPO_4, acetic acid and sodium acetate, K_2HPO_4 and H_3PO_4
C. Chromatography: Separation of sugar and amino acids by paper and thin layer chromatography
D. Colorimetry and spectrophotometry: Estimation of sugar and total carbohydrate, estimation of protein by Lowry, Bradford and UV Spectrophotometry
E. Isolation and characterization of bacterial pigment
F. Studying the stages mitosis in growing tip of onion root cells
G. Computer applications: Using data sheets, and sorting data with different parameters Plotting graphs – bar charts, line graphs, pie charts, adding error bars
H. Statistical analysis of data – Students t test, ANOVA, Chi square test , F test using computer softwares (e.g. Microsoft Excel,Minitab)

Text / Reference Books:

- Alberts Bruce (1985) *Molecular Biology of Cell.*Garland Pub
- Metzler David E. (2001) *Biochemistry: The chemical Reactions of Living Cells*, Volume 1&2, Academic Press California.
- 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
- 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- I)
Paper Code : MICRO4107
Paper : VII
Title of Paper : Skill Development: Spectroscopic Techniques
Credit : 2
No. of lectures : 30

- **Learning Objectives:**
  - ✓ To enrich students' knowledge and train them in the pure microbial sciences
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  - ✓ 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

A. UV-Visible spectroscopy- Principle, Instrumentation. FTIR and its advantages, Principle, Instrumentation, Absorption band
B. Atomic Absorption Spectroscopy(AAS) and its advantages, Hands-on training

Text / Reference Books:

- Wilson Keith and Walker John (2005) *Principles and Techniques of Biochemistry and Molecular Biology,* 6th Ed. Cambridge University Press, New York.
- Pattabhi, V. and Gautham, N. (2002) *Biophysics.* Kluwer Academic Publishers, New York and Narosa Publishing House, Delhi.
- Rolf Ekman, Jerzy Silberring, Ann Westman- Brinkmalm, Agnieszka Kraj (2009) *Mass spectrometry : instrumentation, interpretation, and applications,* John Wiley & Sons, Inc.,Canada.

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2019)
Academic Year 2019-2020

Class : M. Sc. I (Semester- II)
Paper Code : MICRO4201
Paper : I
Title of Paper : Virology
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
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- **Learning Outcome:**
  Enrich students' knowledge and train them in the pure microbial sciences
  Introduce the concepts of application and research in Microbiology

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

- Enveloped and Non enveloped viruses
- Capsid symmetries – Icosohedral, Polyhedral and Helical
- Structural components of virus – Protein - Envelope proteins, Matrix proteins and Lipoproteins, Genome – dsDNA, ssDNA, dsRNA, ssRNA (positive sense, negative sense and ambisense), linear, circular, segmented
- Virus related structures – Viroids and Prions
- **Replication of viruses**
  Mechanism of virus adsorption and entry into host cell
  Genome replication
  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 Cultivation of viruses (15L)

- *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 Hemagglutinationinhibition 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

- T (odd and even phages)
- Lambda phage
- M13 phage
- Phi X 174 phage
- MS2 phage

Bacteriophage therapy for control of bacterial diseases

UNIT 4: Viral Therapeutics (15L)

Vaccines

Conventional vaccines: Killed and attenuated

Modern vaccines: Concepts and examples (DNA vaccines, Recombinant DNA/protein vaccines, Subunits vaccines, Peptide vaccines, Anti-idiotype vaccines, Edible vaccines, Vaccine formulations and delivery: Adjuvants, immunomodulators, cytokines)

Antivirals:

- 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)
- Antiretrovirls
- Mechanism of action
- Mechanism of resistance

Modern approaches of virus control

- Small interfering RNA (siRNA)
- Ribozymes

Text / Reference Books:

- Cann A.J, (2005), Principles of Molecular Virology, 4th Ed. Elsevier Academic Press.
- Dimmock N. J., Easton A. J. and K. N. Leppard, (2007), Introduction to Modern Virology, 6th Ed. Blackwell Publishing.
- Edward K. Wagner, Martinez J. Hewlett, (2004), *Basic Virology*, Blackwell Publishing
- Flint S. J., V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka, (2003), *Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses*, American Society Microbiology.
- Haaheim L. R., J. R. Pattison and R. J. Whitley, (2002), *A Practical Guide toClinical Virology. 2nd Ed.* Edited by, John Wiley & Sons, Ltd.
- 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
- Luria S. E. et.al. (1978) *General virology*, 3rd Ed, New York. John Wiley and Sons.
- Straus J. H. and Straus E.S. (1998) *Evolution of RNA Viruses* Ann. Rev. Microbiol. 42: 657 – 83
- Mahy B. WJ. And Kangro H.O., (1996), Virology Methods Manual, Academic

Press.
- Shors T. (2011), Understanding Viruses, 2nd Ed., Jones & Bartlett Publishers LLC, Canada.
- Stephenson J. R. and Warnes A., (1998), Diagnostic Virology Protocols: Methods in Molecular Medicine, Humana Press.
- Wiedbrauk D. L. and Farkas D.H., (1995) Molecular Methods For Virus Detectin, Academic Press.
- Calendar R. and Abedon S. T. (2006), The Bacteriophages, 2nd Ed. Oxford University Press.
- Douglas John, (1975), *Bacteriophages*, Chapman and Hall, London.
- Guttman Burton S. and Elizabeth M. Kutter, (2002), *Bacteriophage Genetics*,

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.

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2019)
Academic Year 2019-2020

Class : M. Sc. I (Semester- II)
Paper Code : MICRO4202
Paper : II
Title of Paper : Instrumentation
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: Chromatography (15L)

Partition Coefficient, Selectivity, Resolution, Column Efficiency, Van Deemter equation, Interpretation of chromatograms
Principle, components of instrument, operation and application of :

A. Gel filtration chromatography
B. Ion-exchangeChromatography
C. Affinity chromatography
D. Gas chromatography
E. High Performance Liquid Chromatography

UNIT 2 Spectroscopy (15L)

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

A. UV/Visible spectroscopy- Instrumentation, Molar Absorptivities, Beer and Lamberts Law, Bathochromic and hypsochromic shifts.
B. Fluorescence spectroscopy- Instrumentation, Quantum Yield, Quenching, FRET, Binding and Folding studies
C. Infrared spectroscopy- Principle , Instrumentation, Absorption bands, FTIR and its advantages
D. Circular Dichroism (CD) – Instrumentation, Circular polarization, Delta absorbance, Cotton Effect.

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: Microscopy (15L)

Electron microscopy, Immunoelectron microscopy, and Confocal microscopy, Atomic Force

Microscopy, Phase contrast Microscopy, Fluorescence Microscopy

Text / Reference Books:

- Clive Dennison (2002) *A guide to protein isolation*, Kluwer Academic Publishers
- Pattabhi, V. and Gautham, N. (2002) *Biophysics.* Kluwer Academic Publishers, New York and Narosa Publishing House, Delhi.
- David J Holme, Hazel Peck (1998) *Analytical Biochemistry*, 3rd ed ., Prentice Hall, Pearson Education Limited, Harlow England.
- Rodney F. Boyer (2000*) Modern Experimental Biochemistry* 3d edition., Benjamin Cummings.
- Nölting, B. (2006) *Methods in modern biophysics.* Second Edition. Springer, Germany.
- Wilson Keith and Walker John (2005) *Principles and Techniques of Biochemistry and Molecular Biology*, 6th Ed. Cambridge University Press, New York.
- Rolf Ekman, Jerzy Silberring, Ann Westman- Brinkmalm, Agnieszka Kraj (2009) *Mass spectrometry : instrumentation, interpretation, and applications*, John Wiley & Sons, Inc.,Canada.
- Irwin H. Segel (1976) *Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry,* 2nd Edition. John Wiley & Sons.
- 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.

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2019)
Academic Year 2019-2020

Class : M. Sc. I (Semester- II)
Paper Code : MICRO4203
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, energy consideration in photosynthesis, light and dark reaction, electron carriers in photosynthesis, Hill reaction, photolysis of water, C_3, C_4 CAM plants, Photorespiration, Regulation of photosynthesis,
Bacterial photosynthesis: scope, electron carriers, Photosynthetic reaction center, cyclic flow of electrons, bacterial photophosphorylation in various groups of phototrophic bacteria, electron donors other than water in anoxygenic photosynthetic bacteria

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, Biosynthesis of purine and pyrimidine bases

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 acts as terminal electron acceptors

UNIT 4: Enzyme Kinetics (15L)
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:

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

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2019)
Academic Year 2019-2020

Class : M. Sc. I (Semester- II)
Paper Code : MICRO4204
Paper : IV
Title of Paper : Evolution and Ecology
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: Theories of Evolution (30L)

- History and development of evolutionary theories.
- Neo-Darwinism and its importance in prokaryote evolution.
- Spontaneous mutation controversy, evolution of rates of mutation.
- Types and levels of selection
- Neutral evolution and molecular clocks, phylogeny and molecular distances
- Co-evolution.
- Molecular evolution
- Speciation in sexual and asexual organisms, origin and stability of diversity, diversity of secondary metabolites.
- evolutionary stability of cooperation, sociality and multicellularity in microorganisms
- Game Theory

UNIT 2: Ecology (15L)

- The Environment: Physical environment; biotic environment; biotic and abiotic interactions. Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.
- Population Ecology: Characteristics of a population; population growth curves; population regulation;
- Species Interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.
- Community Ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.
- Ecological Succession: Types; mechanisms; changes involved in succession; concept of climax.
- Ecosystem Ecology: Ecosystem structure; ecosystem function; energy flow; Iceland

Geography, primary production and

Text / Reference Books:

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

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2019)
Academic Year 2019-2020

Class : M. Sc. I (Semester- II)
Paper Code : MICRO4205
Paper : V
Title of Paper : Practical Course: Biophysics & Virology
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

A. Qualitative and quantitative detection of bacteriophage
B. Animal virus titration by Hemagglutination test
C. Biological synthesis of nanoparticles (actinomycetes /fungi /yeast) and their characterization by UV-Vis spectroscopy.
D. Interpretation of Ramchandran Plot and study of Conformations of protein molecule using Molecular Graphics Visualization Tool.
E. Calibration of analytical instruments – Colorimeter and Spectrophotometer by estimation of biomolecules and Statistical analysis of data generated.
F. Determination of molar extinction coefficient of biological molecule.
G. To determine the ion-exchange capacity and nature of given resin using anion exchange chromatography.
H. Protein electrophoresis by PAGE and SDS PAGE
I. Agarose Gel Electrophoresis

Text / Reference Books:

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

SYLLABUS (CBCS) FOR M.Sc. I. Microbiology
(w. e. from June, 2019)
Academic Year 2019-2020

Class : M. Sc. I (Semester- II)
Paper Code : MICRO4206
Paper : VI
Title of Paper : Practical Course: Enzymology & Microbial 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

A. Purification of enzyme from natural sources like animal, plant, bacterial/fungal by ammonium sulfate precipitation, organic solvent precipitation, gel filtration, etc.
B. Establishment of enzyme purification chart
C. Determination of Km and Vm values of any hydrolytic enzyme
D. Isolation and characterization of (as nitrogen fixers) *Azospirillum*
E. Detection of IAA by *Azospirillum*
F. Detection of siderophore production by *Azospirillum* and *Pseudomonas*
G. Isolation and characterization of phosphate solublizing bacteria
H. Isolation and characterization of chitin, cellulose and pesticide degrading bacteria
I. Isolation of Aflatoxin producing organism
J. Detection of Aflatoxin in food / culture

Text / Reference Books:

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

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(w. e. from June, 2019)
Academic Year 2019-2020

Class : M. Sc. I (Semester- II)
Paper Code : MICRO4207
Paper : VII
Title of Paper : Skill Development: Chromatographic Techniques
Credit : 2
No. of lectures : 30

- **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

A. High Performance Liquid Chromatography (HPLC)
Fundamentals and Principles of High Performance Liquid Chromatography (HPLC), Instrumentation, Types of HPLC–Normal phase HPLC, Reverse Phase HPLC, Ion Exchange Chromatography (IEC), Size exclusion chromatography, Mobile phases, Sample preparation, Hands on training

B. Gas Chromatography (GC)
Fundamentals and Principles of Gas Chromatography (GC), Instrumentation, Sample preparation, Mobile phases, Injectors, GC columns, GC detectors
Hands-on training

Text / Reference Books:

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