UNIVERSITY OF PUNE

M. Sc. (MICROBIOLOGY)

REVISED SYLLABUS FOR POST GRADUATE COURSE IN MICROBIOLOGY

M. Sc. Part I – w. e. f. June 2008
M. Sc. Part II – w. e. f. June 2009
GENERAL INSTRUCTIONS

1. Eligibility: B. Sc. with Microbiology as principle subject and performance at entrance examination (as per the requirement of the center).

2. Distribution of University and Departmental Courses:

<table>
<thead>
<tr>
<th>Semester</th>
<th>University Courses</th>
<th>Departmental Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>MB – 501, 502, 503</td>
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<tr>
<td></td>
<td>MB – 511, 512</td>
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<tr>
<td>II</td>
<td>MB – 601, 602, 603</td>
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<tr>
<td></td>
<td>MB – 611, 612</td>
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<tr>
<td>III</td>
<td>MB – 701, 702, 703</td>
<td>MB – 711, 712</td>
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<tr>
<td>IV</td>
<td>MB – 801, 802, 803</td>
<td>MB – 811, 812</td>
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</tbody>
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3. Examination of practical courses of Semester - I i.e. MB - 511 and MB - 512 and practical courses of Semester - II i.e. MB - 611 and MB - 612 shall be examined at the end of respective Semester. The practical examination for Semester – I will be after theory examination. These four practical courses will be treated as University courses and will be examined by the examiners appointed by University of Pune, Pune.

4. Practical courses of Semester - III i.e. MB - 711 and MB - 712 and practical courses of Semester - IV i.e. MB – 811 and MB – 812 (Dissertation in place of practical course) shall be examined at the end of academic year i.e. in the month of April / May of the respective academic year. These four Practical courses will be treated as Departmental courses and examination will be conducted by the concerned department.

5. Practical for course no. MB - 711 and MB - 712 will be conducted throughout the academic year while students can carry out the dissertation work throughout the year.

6. The format for dissertation will be similar to the research thesis style; incorporating chapters on: Introduction, Materials and Methods, Results and Discussion and References / Bibliography. The dissertation will be submitted in a typewritten and bound form. Copy of each dissertation will be submitted to the respective department and the center will store it permanently.

7. Each Laboratory course will occupy six hours / week.

8. Dissertation will occupy equivalent to two laboratory courses i.e. 12 hours a week.

9. Dissertation will be compulsory to all students. Students will carry out dissertation work individually or in the group of not more than three students.

10. Concerned department shall provide all required infrastructure to carry out dissertation work.
11. Every student will write a review article every semester, based on original and recently published research papers.

12. Every student will give one oral presentation each semester, which will be evaluated by the faculty. Marks for review and the oral presentation will be suitably incorporated in the internal assessment of the practical courses.

13. Question paper for each theory course will include at least one problem based on research reports (Mathematical / Data Interpretation / Comment type) related to concerned course.
## M. Sc. (Microbiology) Curriculum

### Semester I:
- **Theory Course I** - MB-501  
  Microbial Diversity and Taxonomy  
- **Theory Course II** - MB-502  
  Quantitative Biology  
- **Theory Course III** - MB-503  
  Cell Organization and Biochemistry  
- **Practical Course I** - MB-511  
  Microbial Diversity and Systematics  
- **Practical Course II** - MB-512  
  Cell Biology and Biochemistry  

### Semester II:
- **Theory Course I** - MB-601  
  Instrumentation and Molecular Biophysics  
- **Theory Course II** - MB-602  
  Evolution, Ecology and Environmental Microbiology  
- **Theory Course III** - MB-603  
  Microbial Metabolism  
- **Practical Course I** - MB-611  
  Ecology and Environmental Microbiology  
- **Practical Course II** - MB-612  
  Enzymology and Microbial Metabolism  

### Semester III:
- **Theory Course I** - MB-701  
  Immunology  
- **Theory Course II** - MB-702  
  Molecular Biology I  
- **Theory Course III** - MB-703  
  Virology  
- **Practical Course I** - MB-711  
  Biotechnology and Scientific Communication  
- **Practical Course II** - MB-712  
  Molecular Biology and Immunology  

### Semester IV:
- **Theory Course I** - MB-801  
  Pharmaceutical and Medical Microbiology  
- **Theory Course II** - MB-802  
  Molecular Biology II  
- **Theory Course III** - MB-803  
  Microbial Biotechnology  
- **Practical Course I** - MB-811  
  Research Methodology – I (Dissertation)  
- **Practical Course II** - MB-812  
  Research Methodology – II (Dissertation)
SEMESTER – I

Theory Course I – MB-501: Microbial Diversity and Taxonomy

A. Taxonomy (22)
1. Methods in Taxonomy of Bacteria, Archaea and Fungi:
   1. Morphological Methods
   2. Chemotaxonomy
   3. Genetic Methods
   4. Methodology of rRNA sequencing (teach as per practical / experimental methods)
2. Methodology of identification of unknown pure cultures: Strategy and methods

B. Diversity (16)
The expanse of microbial diversity, estimates of total number of species, measures and indices of diversity.
Newer approaches for exploring unculturable bacteria from environmental samples like sewage
Culture independent molecular methods, Methods of extracting total bacterial DNA from a habitat.

C. Bioinformatics (10)
Sequence alignment, scoring matrices, local and global alignment, dynamic methods, Needleman and Wunsch algorithm, Smith-Waterman algorithm, database search for homologous sequences, BLAST and FASTA versions.

References:

Taxonomy

Diversity

**Bioinformatics**

Theory Course II – MB – 502: Quantitative Biology

A) Biostatistics
Quantitative methods in biology, sampling methods, scales and variables, data organization, tabulation, graphical representation
Concepts, examples and problems for each of the following:

b. Regression and correlation, curve fitting and choice of models.
c. Introduction to multivariate analysis: multiple regressions, ordination, principal component analysis.
d. Survey design
e. Factorial design, ANOVA and F test.
f. Probability: Laws of probability, independence and randomness
g. Hypothesis testing: comparison of two sample means: t-tests, non-parametric tests. The concepts of null hypothesis, significance level, type I and type II errors, one tailed and two tailed tests.
h. Categorical data and proportion data: Chi square test and test for goodness of fit.

B) Modeling in Biology
1. Concept and applications of modeling:
   a. Population models: Exponential, logistic and chemostat models.
   b. Models in population genetics, models based on Hardy-Weinberg equation.
   c. Introduction to the concept of stochastic models.
   d. Epidemiological models

2. Use of Computers in Biology
   a. Concept and applications of databases
   b. Concept and applications of internet
   c. Computer simulation of biological systems, writing simple simulation programs for growth models, population interactions and pathway regulation.

References:
Theory Course III – MB – 503: Cell Organization and Biochemistry

A) Introduction to Bioorganic Chemistry
   (10)
   a. Chemical reactivity: Concept and factors affecting reactivity (Inductive effect, Resonance / Mesomeric effect, Conjugation and Hyper-conjugation, Tautomerism, etc.)
   b. Bonding other than covalent – H-bonds, Van der Wall’s interaction, charge transfer complexes, ionic bonding, Ion-dipole, Host-guest interactions
   c. Reactions of organic molecules: A brief overview of important reactions in organic chemistry e.g. Substitution, Addition, Elimination, Rearrangement, Oxidation, Reduction, etc.
   d. Stereochemistry: Three dimensional shape of molecules, conformation and configuration, structure and biological activity
   e. Bioorganic mechanisms of enzyme catalyzed reactions: stereochemical aspect of inhibition by penicillin
   f. Concept of pH of weak acids and weak bases, Henderson-Hasselbalch equation, concept of buffer, strength of buffer, buffer value, important biological buffers (with the help of numerical problems)

B) Chemical Composition of Living Systems

Protein Chemistry:  (3)
   Structural features of amino acids, classification of amino acids, amino acids as buffers, chemical reactions of amino acids, peptide linkage, partial double bond nature of peptides, determination of primary structure of polypeptide (N-terminal, C-terminal determination, method of sequencing of peptides), structural classification of proteins, primary, secondary, tertiary, quaternary structures of proteins, protein detection and estimation.

Carbohydrate Chemistry:  (3)
   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, estimation of carbohydrates

Nucleic acid Chemistry:  (3)
   Structure of bases, nucleosides, nucleotides, phospho-diester 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, structure of t-RNA, r-RNA, and m-RNA, estimation of nucleic acids

Lipid Chemistry:  (3)
   Classification of lipids according to chemical structure, fatty acids, saturated, unsaturated, branched, nomenclature, system structure and function of triglycerides, phospholipids, sphingolipids, terpenes, prostaglandins, waxes, steroids, detection and estimation of lipids

Vitamins:  (2)
   Structure and function of fat soluble vitamins as vitamins A, D, E and K

C) Ultrastructure and Organization of Eukaryotic Cell
   (12)
   Structural organization of: Cytoskeleton (structural proteins – microfilaments, actins, etc.); nucleus, Mitochondria and chloroplasts and their genetic organization, Endoplasmic Reticulum, Golgi apparatus, Protein trafficking; Events in cell cycle, Regulation of cell cycle.
Localization of macromolecules using electron microscopy, Immuno-electron microscopy, Confocal microscopy

D) Development And Differentiation
(6)
Introduction to Developmental Biology, Conserved nature of development, Importance of its regulation, Concepts of commitment, determination and differentiation, dedifferentiation, re-differentiation and trans-differentiation, teratogenesis, morphogen gradients in developmental regulation, Hox code, MPF, homeostasis, cell proliferation and cell death, apoptosis, gastrulation and cellular movements involved in it, organizer and its importance giving examples of invertebrates (Drosophylla) and vertebrate (Xenopus) model systems, pattern formation in body axis, antero-posterior and dorso-ventral polarity

E) Communication And Coordination
(6)
Cell signaling and communication in Dictyostlium, Myxobacteria, quorum sensing. Biofilms and their application

References:

Introduction to Bioorganic Chemistry

Ultrastructure and Organization of Eukaryotic Cell

Development and Differentiation

Chemical Composition of Living Systems


**Communication and Coordination:**


Practical Course I – MB – 511: Microbial Diversity and Systematics

1. Isolation, identification and characterization of actinomycetes
2. Isolation, identification and characterization of yeast
3. Isolation, identification and characterization of molds
4. Isolation and characterization of anaerobic microorganisms
5. Isolation and characterization of thermophilic microorganisms
6. Isolation and characterization of cyanobacteria
7. Isolation and characterization of halophiles
   (One isolate from all the groups 1 to 7 and identification upto genus level)
8. Molecular Taxonomy:
   a. Isolation, purification and estimation of chromosomal DNA of bacteria
   b. Isolation, purification and estimation of RNA from Yeast
   c. Sequence matching using BLAST, RDP.

Practical Course II – MB – 512: Cell Biology and Biochemistry

1. 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
2. Buffer: Determination of pKa of a monoprotic weak organic acid; Preparation of buffers using KH$_2$PO$_4$ and K$_2$HPO$_4$, acetic acid and sodium acetate, K$_2$HPO$_4$ and H$_3$PO$_4$
3. Chromatography: Separation of sugar and amino acids by paper and thin layer chromatography
5. Computer applications: Plotting graphs, Statistical analysis using Excel, simulation of population growth in batch and continuous culture
6. Electrophoresis: Agarose gel electrophoresis, PAGE and SDS-PAGE of proteins
7. Determination of sugars (qualitative) in cell walls of actinomycetes
8. Isolation and characterization of bacterial pigment
9. Detection, isolation and characterization of PHB granules in bacteria
10. Determination of saponification value and iodine number of fat
SEMMESTER – II

Theory course I – MB – 601: Instrumentation and Molecular Biophysics

A) Instrumentation: Principles and applications of: (24)

1. Chromatographic techniques: Basic concepts, Gel filtration chromatography, Ion-exchange chromatography, Affinity chromatography, Gas Liquid Chromatography, High Performance Liquid Chromatography
2. Electrophoresis: Basic concepts, Gel Electrophoresis – agarose and acrylamide (Native, denaturing: gradient), Isoelectric focusing
3. Centrifugation: Basic concepts, Ultra centrifugation, Density gradient centrifugation, Differential centrifugation, Isopycnic centrifugation
4. Spectroscopy: Basic concepts, UV/Visible spectroscopy, Circular Dichroism (CD) and Optical Rotatory Dispersion (ORD), Fluorescence spectroscopy, Infrared spectroscopy, FTIR
5. Radiography: Tracer elements in Biology, Radioisotopes and their characteristics, Autoradiography, Pulse chase experiment, Čerenkov radiation, Liquid scintillation counting, Phosphor imaging

B) Molecular Biophysics

1. Properties of amino acids and peptides: (5)
   Physical and chemical properties of amino acids, Theoretical and experimental methods for determination of size of proteins, Physical nature of non-covalent interactions, Conformational properties of proteins, Ramachandran plot, Secondary, super-secondary, tertiary and quaternary structures of proteins, Classification of three dimensional structures of proteins (motifs and fold domains)
2. Protein structure / properties determination:
   a. Experimental techniques: (15)
      i. X-ray crystallography: Isolation and purification of proteins, crystallization of proteins, instrumentation, acquisition of the diffraction pattern, basic principles of x-ray diffraction, Phase determination
      ii. NMR spectroscopy: Basic Principles of NMR, Chemical shift, Intensity, Line width, Relaxation parameters, Spin-spin coupling, Nuclear Overhauser Effect, NMR Applications in Biology
      iii. Mass spectroscopy: Principles of operation and types of spectrometers, ionization, Ion transport and ion detection, Ion fragmentation, Combination with chromatographic methods, Biological applications, MALDI-TOF
   b. Theoretical methods (Concept and introduction): (4)
      Lim’s stereochemical method, Chou-Fasman method, Garnier-Osguthorpe-Robson (GOR) method, Neural networks, Homology based methods

References:

Instrumentation

**Molecular Biophysics**

**Other books:**
Theory course II – MB – 602: Evolution, Ecology and Environmental Microbiology

A) Evolution: (15)

History and development of evolutionary theory
Neo-Darwinism: Spontaneous mutation controversy, evolution of rates of mutation, types of selection, levels of selection, group selection and selfish gene.
Speciation in sexual and asexual organisms, origin and stability of diversity, diversity of secondary metabolites

B) Ecology: (15)

1. Community ecology: community structure, benevolent interactions (control within the microbial communities of rhizosphere), antagonistic interactions, (competition, antibiosis, predation etc.). Rhizosphere, rhizoplane, siderophore, flavonide from plants, lectines, octapine, nipotine, indole acetic acid.

C) Wastewater Treatment and solid waste management: (18)

1. Wastewater treatment system (unit process): Physical screening, flow equalization, mixing, flocculation, flotation, sedimentation, granular medium filtration, adsorption, Bioremediation and phytoremediation
2. Chemical precipitation, gas transfer, disinfection, dechlorination
3. Biological: (aerobic and anaerobic, suspended and attached growth processes.) Working treatment systems and their analysis (reactions and kinetics, mass balance analysis, reactor types, hydraulic character of reactors, selection of reactor type.) Critical operating parameters like DO, hydraulic retention time, mean cell residence time, F/M ratio etc. Malfunctioning of treatment systems due to shock loading, hydraulic loading etc. and remedial measures adapted.
4. Effluent and sludge disposal, control and reuse. Water pollution control, Regulation and limit for disposals in the lakes, rivers, oceans, and land. Direct and indirect reuse of treated effluents and solid wastes.
5. Current industrial wastewater treatment and disposal processes (Sugar and distillery, Textile, dyestuff, dairy, paper and pulp manufacturing industries)
6. Approaches to solid waste management using composting, vermiculture and biomethanation methods and their suitability to environment
References:

Evolution:

Ecology

Waste Water Treatment:
Theory course III - MB – 603: Microbial metabolism

A) Bioenergetics: (6)
Laws of thermodynamics, entropy, enthalpy, free energy, free energy and equilibrium constant, Gibbs free energy equation, determination of free energy of hydrolytic and biological oxidation reduction reactions, under standard and non-standard conditions, high energy compounds, coupled reactions, determination of feasibility of reactions.

B) Enzymes: (10)
Purifications of enzyme, purification chart, kinetics of single substrate enzyme catalyzed reaction. Kinetics of reversible inhibitions enzyme catalyzed reactions, 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 (Monad, Wyamann and Changua and Koshland, Nemethy and Filmer model), kinetics of allosteric enzyme, Hill plot, examples of allosteric enzymes and their significance in allosteric regulation.

C) Aerobic Respiration: (6)
Mitochondrial electron transport chain, structure and function of ATPase (bacterial and mitochondrial), generation and maintenance of proton motive force, oxidative phosphorylation, inhibitors and un-couplers of electron transport chain and oxidative phosphorylation, Atkinson’s energy charge, phosphorylation potential and its significance, Energy generation in all groups of chemolithotrophs.

D) Anaerobic Respiration: (4)
Concept of anaerobic respiration, oxidized sulfur compounds, and nitrate as electron acceptor with respect to electron transport chain and energy generation, Biochemistry of methanogenesis, Biochemistry of ammonia oxidation

F) Nitrogen Metabolism: (10)
  a. 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
  b. Biosynthesis of five families of amino acids and histidine, Biosynthesis of purine and pyrimidine bases

G) Photosynthesis: (6)
Energy consideration in photosynthesis, light and dark reaction, electron carriers in photosynthesis, Organization of photosystem I and II, cyclic and non-cyclic flow of electrons, Z scheme, Hill reaction, photolysis of water. 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.

F) Membrane Transport: (6)
The composition and architecture of membranes, Membrane dynamics, Solute transport across membranes: Passive diffusion, active transport using P and F type ATPases, Ion mediated transport, transport of ions across membranes (ion pumps), Model membranes; Liposomes
References:
Practical course I – MB – 611: Ecology and Environmental Microbiology

1. Determination of DO, COD and BOD
2. Determination of TS and MLSS
4. Isolation of cellulose degraders
5. Isolation of chitinase degraders
6. Isolation of pesticide degraders.
7. Estimation of microbial species diversity in microecosystem
8. Effect of stress Temperature, pH, salt concentration, nitrate, phosphate) on microbial species diversity.
9. Isolation of Aflatoxin producing organism
10. Detection of Aflatoxin in food / culture

Practical course II – MB – 612: Enzymology and Microbial Metabolism

1. Calibration of analytical instruments – Colorimeter and Spectrophotometer by estimation of biomolecules and statistical analysis of data generated.
2. Determination of molar extinction coefficient of biological molecule
3. Purification of enzyme from natural source by (any one method): Ammonium sulfate precipitation, Organic solvent precipitation, Gel filtration
4. Determination of Km and Vm values of Invertase
5. Determination of Km and Vm values of Amylase
6. Electrophoretic Techniques: Protein electrophoresis by PAGE and SDS PAGE
7. Isolation and characterization of (as nitrogen fixers) of *Azospirillum* and detection of IAA by *Azospirillum*
8. Detection of siderophore production by *Azospirillum* and *Pseudomonas*
9. Isolation and characterization of chemolithotrophic microorganisms
10. Interpretation of Ramchandran Plot