

UNIVERSITY OF PUNE

M. Sc. (MICROBIOLOGY)

**REVISED SYLLABUS FOR
POST GRADUATE COURSE IN MICROBIOLOGY
(2008 Pattern)**

M. Sc. Part I – w. e. f. June 2008

M. Sc. Part II – w. e. f. June 2009

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	Microbial Technology
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 Technology

Practical Course I	- MB-811	Research Methodology I (Dissertation)
Practical Course II	- MB-812	Research Methodology II (Dissertation)

GENERAL INFORMATION

1. **M. Sc. Microbiology (non-credit system)** is a two year postgraduate course, comprising four semesters. At each semester there will be five courses of which 3 are theory courses and 2 laboratory (practical) courses.
2. **Eligibility:** B. Sc. with Principle subject Microbiology. The concerned centers may conduct their own entrance examination, for admission.
3. **Medium of instruction** – English

4. **Distribution of University and Departmental Courses:**

	University Courses	Departmental Courses
Semester - I	MB – 501, 502, 503 MB – 511, 512	---
Semester - II	MB – 601, 602, 603 MB – 611, 612	---
Semester – III	MB – 701, 702, 703	MB – 711, 712
Semester - IV	MB – 801, 802, 803	MB – 811, 812 (Dissertation)

5. **Practical** for course no. MB-711 and MB-712 will be conducted throughout the academic year for M. Sc part–II students, while students can carry out the dissertation (practical course MB-811 and MB-812) work throughout the year.
6. **Workload:** The contact period for each semester will be 12 weeks, 4 lectures per course per week, each of 60 minutes duration. Work load for theory courses of college teacher entrusted with work of post-graduate teaching will be at the rate of one clock hour of post-graduate teaching equal to two periods of undergraduate teaching. Each laboratory course will occupy six hours / week / batch. The work-load for seminars / oral presentations of students will be 4 periods per week per class (M. Sc Part–I and M. Sc. Part–II). Dissertation will occupy equivalent workload of two laboratory courses i.e. 6 hours a week / practical course / batch.
7. **Dissertation** will be compulsory to all students. Students will carry out dissertation work individually or in the group of not more than three students. Concerned department shall provide all required infrastructure to carry out dissertation work. The format for dissertation report 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.
8. **Review writing and Seminars:** Every student will write a review article every semester, based on original and recently published research papers. 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.

9. **Examination** will be held at the end of each semester. Each course carries 100 marks, the distribution of which is 80 marks for external examination and 20 marks for internal examination. All theory courses are University courses, the examination (external examination) will be for 80 marks and for duration of 3 hours.
10. **Examination of practical courses** of Semester-I (MB-511 and MB-512) and practical courses of Semester-II (MB-611 and MB-612) shall be examined at the end of respective Semesters. The practical examination for Semester-I will be after the 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. The practical examination will be conducted for 3 consecutive days, for minimum 6 hours / day / batch. Practical examination of departmental courses will be conducted by respective centers either by continuous evaluation system or on similar lines as university courses.
Practical courses of Semester-III (MB-711 and MB-712) and practical courses of Semester-IV (MB-811 and MB-812 - Dissertation) 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.
11. **The examination for internal marks** will be conducted by respective departments throughout the semester.
12. **Dissertation evaluation:** Student/s will submit one copy of the dissertation report to the department. If there is more than one student carrying out a single dissertation, a single report can be submitted and these students will be assessed based on single oral presentation. In such case, presentation should be carried out by all the students carrying out the same work; dividing the presentation equally among them. Evaluation of dissertation will be carried out by two examiners appointed by the concerned department, one of which will be the project guide / supervisor. Student/s will make a oral presentation of the work to an audience comprising of examiners, departmental teaching staff and the postgraduate students of the department. Oral presentation can be carried out using posters, blackboard, transparencies or LCD projector. The allotted time for each oral presentation (one project) should be 10 to 12 minutes, followed by question-answer session of 5 to 8 minutes. The audience can participate in this session
The suggested guidelines for evaluation of dissertation work are:
Intellectual potential (Understanding of the research problem by the student), Research aptitude (Depth of literature survey for the proposed work, Inputs of student in development of plans and protocols for the experimentation, Ability to analyze data and formulate a solution, Analytical and reasoning abilities of the student for interpretation of data, inputs in discussion), Motivation (punctuality, meeting deadlines and seriousness), Ability to work with others, Maturity of scientific thoughts, Communication skill (oral and written), Proficiency of presentation skills (use of audio-visual aids, preparation of graphs, charts, models, etc., use of scientific language, etc.), Research potential of the work (results and interpretation, outcome of the study and possible future plans, publication potential of the work), The dissertation report preparation (scientific writing) and its contents, Satisfactory responses to the queries from the audience during open defense, etc.

13. **Examination for theory examination:** Question paper will comprise of 5 questions, 16 marks each. Number of questions on the topic should reflect in the weightage of the topic in the syllabus. Sufficient option of questions should be allowed in the question papers, but not exceeding 50 % of maximum marks. Question paper for each theory course will include at least one compulsory problem-question based on research reports (Mathematical / Data Interpretation / Comment type) related to concerned course. Essay type questions should not be asked.
14. **Standard of Passing:** The award of class / grades, ATKT and marks for passing, etc. will be as per the University of Pune rules.

The equivalence of the previous syllabus (2005 pattern) with this syllabus (2008 pattern) is as follows:

M. Sc. Microbiology Syllabus Equivalence

Old syllabus (implemented from June, 2005) and

New syllabus (implemented from June, 2008)

Equivalence to			
OLD SYLLABUS (June 2005)		NEW SYLLABUS (June 2008)	
Course Number	Title	Course Number	Title
M. Sc. Part – I Semester – I			
Theory course I – MB-501	Microbial Diversity and taxonomy	Theory Course I - MB-501	Microbial Diversity and Taxonomy
Theory course I – MB-502	Quantitative Biology	Theory Course II - MB-502	Quantitative Biology
Theory course I – MB-503	Organization of living systems	Theory Course III - MB-503	Cell Organization and Biochemistry
Practical course I- MB-511	Microbial diversity, Systematics and Scientific communication	Practical Course I - MB-511	Microbial Diversity and Systematics
Practical course I- MB-512	Essential laboratory techniques, Biochemistry and cell biology	Practical Course II - MB-512	Cell Biology and Biochemistry
M. Sc. Part I Semester – II			
Theory course I – MB-601	Virology	<i>Semester III</i> Theory Course III - MB-703	Virology
Theory course I – MB-602	Evolution, Ecology and Environmental Microbiology	Theory Course II - MB-602	Evolution, Ecology and Environmental Microbiology
Theory course I – MB-603	Microbial Metabolism	Theory Course III - MB-603	Microbial Metabolism
Practical course I- MB-611	Ecology, Environmental Microbiology and Environmental toxicology	Practical Course I - MB-611	Ecology and Environmental Microbiology
Practical course I- MB-612	Microbial Metabolism, Tissue culture and Virology	Practical Course II - MB-612	Enzymology and Microbial Metabolism

Equivalence to			
OLD SYLLABUS (June 2005)		NEW SYLLABUS (June 2008)	
Course Number	Title	Course Number	Title
M. Sc. Part II Semester III			
Theory course I – MB-701	Immunology.	Theory Course I - MB-701	Immunology
Theory course II- MB-702	Molecular Biology I	Theory Course II - MB-702	Molecular Biology I
Theory course II- MB-703	Biophysics, Instrumentation and Bioinformatics	Semester II Theory Course I - MB-601	Instrumentation and Molecular Biophysics
Practical course MB-711	Immunology, Biophysics and Instrumentation	Practical course MB-711	Microbial Technology
Practical course MB-712	Molecular Biology, Bioinformatics and Applied	Practical course MB-712	Molecular Biology and Immunology
M. Sc. Part II Semester IV			
Theory course I - MB-801	Applied Microbial Biotechnology	Theory Course III- MB-803	Microbial Technology
Theory course II – MB-802	Pharmaceutical Microbiology	Theory Course I- MB-801	Pharmaceutical and Medical Microbiology
Theory course III- MB-803	Molecular Biology II	Theory Course II- MB-802	Molecular Biology II
Practical course MB-811	Dissertation.	Practical Course I - MB-811	Research Methodology I (Dissertation)
Practical course MB-812	Dissertation.	Practical Course II - MB-812	Research Methodology II (Dissertation)

Salient Features of M. Sc. Microbiology curriculum (Implemented from June, 2008)

The objectives of postgraduate training are orienting the students for research towards higher degrees, or in the field of development of industrial processes. The expectations and opportunities available for Masters Students are responsible positions in technical production, planning and policy making, both in research and industry. Though all postgraduate students do not undertake research career, but all the researchers necessarily come from postgraduates in the subject and therefore postgraduate curriculum in all its different aspects such as design, implementation and evaluation needs necessarily to be research oriented. Imparting in-depth fundamental knowledge of the diverse areas of the discipline, combined with acquaintance with front-line research trends and developments in related field is the aim of postgraduate curricula. The curriculum should be designed in such a way, that after their postgraduate studies, students should be able to work directly in the applied field (industry or research institute) without any additional special training. After completing this curriculum the students should be able to take up the following responsibilities:

1. Research at national, international level.
2. Higher positions in biotech production units
3. Planning and policy making for biotechnology
4. Teaching at undergraduate / postgraduate level courses in Microbiology / Biotechnology

To keep the syllabus relevant to national needs, the guidelines from CSIR and UGC curricula for research fellowship were taken into account. Syllabus reforms involved discussions with experts from educational institutes, research and industry as well as few past and present students.

Dissertation at M. Sc. Part II: The suggestions received from Peers regarding postgraduate dissertations state that:

1. With increasing number of students every year it has become difficult for students to find placement to do research project for dissertation. Research laboratories are finding it difficult to provide facilities for number of students. These laboratories accept only a limited number of students.
2. Teachers and Heads of the Postgraduate Department / Centers should take equal interest in these dissertations and should stay in communication with the research guide for the dissertation regarding progress of work. Teachers should also see that the results of dissertation do not go waste and attempt to publish it in the form of a scientific publication.
3. As per earlier syllabus structure, the dissertations were evaluated by University appointed examiners and only two examiners (Internal and External) evaluated all the dissertations from diverse research areas (even though, they may not have had the expertise in all areas!). This seems to be unjust for the students as well as examiners. A decision was taken that the dissertation work (in lieu of practical course) will be treated as departmental course, instead of University course; thus allowing for flexibility and freedom for concerned centers to appoint examiners with expertise and research experience / interests in the topic of research work carried out by the candidates.

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 opt 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, Archeobacteria, 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.

Thus, the structure of the M. Sc. Microbiology syllabus is as follows:

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

The theory and practical courses will encompass the microbial world – its extent and spread with examples, acquaint the students with traditional and biochemical as well as molecular tools and bioinformatics tools to study the microbial diversity. The course contents deal with cellular organization focusing on eukaryotic cell, since prokaryotic especially bacterial cell structure was dealt with in under-graduation. Quantitative biology is supportive to these aspects and also prepares the students for data handling and processing strategies that is an integral part of research and applied science.

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

Once the knowledge base of microbial world is build up, the methodology to study life processes will be introduced. This includes metabolism, Enzymology, analytical and quantitative instrumentation and biophysics. The biophysical studies have lot of potential in genomics, proteomics and drug discovery. At this stage some theoretical biology aspects (evolution) and applied aspects (environmental) have also been introduced. The laboratory work in these areas will help the students to develop practical applications in these areas.

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	Microbial Technology
Practical Course II	- MB-712	Molecular Biology and Immunology

At the end of first part of postgraduate studies, students have now developed knowledge base in the life science fundamentals and will be ready to study different tools like immunology and molecular biology. The compartmentalization of pure sciences will now start disappearing and students will be ready to undertake studies in life sciences, in general. The virology is such an area that deals with different aspects of life, like biochemistry, biophysics, instrumentation, molecular biology, tissue culture, etc. with a

specific application as tool in cell biology. All three theory papers will deal with basic concepts as well as research, evolution, genomics and applied approaches. The experimentation part in theory and practical will be helping the students to develop skill-sets necessary for work in any specific areas of life science and biotechnology.

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 Technology
Practical Course I	- MB-811	Research Methodology – I (Dissertation)
Practical Course II	- MB-812	Research Methodology – II (Dissertation)

The last semester of deals entirely with applied approach in different areas of life sciences with specific examples from microbial sciences. The drug discovery and development can be carried out using traditional methods as well as modern tools like molecular biology, proteomics, biophysics and students will be ready to tackle this challenging field. The medical microbiology is presently hot field for research in India and abroad and presently there is dearth of expertise. We are confident that postgraduate microbiology degree holder will provide the required theoretical and laboratory expertise needed by biotech industry and life-science research institutes.

Research aptitude development: The students are trained in different areas that are required to develop research aptitude viz. collection of background information and tracking the developments in a particular research topic, planning experimentation, execution, data analysis and interpretation, presentation – oral and in writing. The M. Sc. Microbiology students are required to make a presentation of a published research paper in the form of seminar, every semester. Students are also required to write a review of literature on a specific topic dealing with frontline research at M. Sc. part I and part II. With the change in structure of departmental and university courses, the dissertation work will now be spread over two semesters, providing sufficient time for undertaking thorough study and execution of a research topic. With the theoretical and practical training in biostatistical tools, scientific writing, seminars and review writing; students will be capable of carrying out quality research for their dissertation work.

We submit here that total change in course content is not possible, since the teachers will have to upgrade their knowledge and skills in these areas which is a slow process. However, we would like to assure that given time, the Microbiology faculty is capable of adjusting to these changes. In some areas, the expertise may not be presently available and collaboration with industry and research institutions is necessary. This should also help to develop fruitful interactions between academicians, researchers and industry; benefiting the faculty and ultimately the students.

**Members, Sub-committee for M. Sc. Microbiology Syllabus
Members, Board of Studies in Microbiology
December, 2008.**

SEMESTER – I

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

A. Taxonomy (22)

1. Methods in Taxonomy of Bacteria (including archaeobacteria,) 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:

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

1. Barnett, H. L. and Hunter, B. B. 1960. *Illustrated Genera of Imperfect Fungi*. Burgess Publishing Co., Minnesota.
2. Breed and Buchanan. *Bergey's Manual of Determinative Bacteriology*. 8th Edition, 1974.
3. Breed and Buchanan. *Bergey's Manual of Determinative Bacteriology*. 9th Edition, 1982.
4. Breed and Buchanan. *Bergey's Manual of Systematic Bacteriology*. 2nd Edition, (Volumes. 1 – 5) (2001 – 2003).
5. Lodder J. (1974). *The Yeasts: A Taxonomic Study*, North Holland Publishing Co. Amsterdam.
6. Sykes, G. and F. A. Skinner (Eds). *Actinomycetales: Characteristics and Practical Importance*. Society for Applied Bacteriology Symposium Series No. 2, Academic Press. 1973.

Diversity

1. Amann R. Ludwig W. and Schleifer K. (1995). *Phylogenetic Identification and In situ detection of Individual Microbial Cells Without Cultivation*, Microbiological Reviews **59**, 143-169.
2. Cook T. (2002) *Microbial Biodiversity: Saving Bacteria to save ourselves*, Harvard Science Review, 26-28.
3. Hugenholtz P. (2002) *Exploring Prokaryotic Diversity in the Genomic Era*, Genome Biology, **3**(2), 0003.1-0003.8.

4. Keller M. and Zengler K. (2004) *Tapping in to Microbial Diversity*. Nature Reviews **2**, 141-150.
5. Pace N. (1997) *A Molecular View of Microbial Diversity and the Biosphere*, Science, **276**, 734-740.
6. Woese C. (1987), *Bacterial Evolution*. Microbiological Reviews, 221-271.

Bioinformatics

1. Baldi, P. and Brunak, S. (2001) *Bioinformatics: The machine learning approach*. Bradford Book, MIT Press, Cambridge.
2. Baxevanis, A. D. and Ouellette, B. F. F. (2001) *Bioinformatics: A practical guide to the analysis of genes and proteins*. Second Edition. John Wiley & Sons, New York.
3. Ewens Warren J. and Gregory R. Grant. (2004) *Statistical Methods in Bioinformatics, An Introduction*, Springer, New York.
4. Lacroix, Z. and Critchlow, T. (Eds.) 2003. *Bioinformatics. Managing Scientific Data*. Morgan Kaufmann Publishers.
5. Misener, S. and Krawetz, S. A. (Eds.). 2000. *Methods in Molecular Biology*, Volume 132. Bioinformatics: Methods and Protocols. Humana Press, New Jersey.
6. Mount, D. W. (2001) *Bioinformatics: sequence and genome analysis*. Cold Spring Harbor Laboratory Press, New York.
7. Zoe L. and Terence C. (2004) *Bioinformatics: Managing Scientific Data*, Morgan Kaufmann Publishers, New Delhi.

SEMESTER – I
Theory Course II – MB – 502: Quantitative Biology

A) Biostatistics (28)

Quantitative methods in biology, sampling methods, scales and variables, data organization, tabulation, graphical representation

Concepts, examples and problems for each of the following:

- a. Descriptive statistics: Frequency and probability distributions, graphical representation of distributions, measures of central tendency, measures of dispersion, skewness, kurtosis. Introduction to Normal, Binomial and Poisson distributions and their applications. Distribution of sample means, standard error and confidence interval.
- 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: (10)

- 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 (10)

- 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:

1. Brown D. & P. Rothery (1993) *Models in Ecology*, Wiley
2. Cochran W.G. – *Sampling Techniques*, Wiley eastern Ltd, New Delhi.
3. Feller W. – *Introduction to probability theory and its applications*, Asia Publishing House, Mumbai.
4. Goon, Gupta and Dasgupta – *Fundamentals of statistics*, World Press, Kolkata.
5. Gupta S.P.- *Statistical methods*, Sultanchand & Sons.
6. Haefner James W. (1996) *Modeling Biological Systems : Principles and Applications*, Kluwer Academic Publications
7. Irfan Ali Khan and Atiya Khanum, *Fundamentals of Biostatistics*. 2nd Ed. Ukaaz Publications, Hyderabad.

8. John Maynard Smith (1974) *Models in Ecology*, Cambridge University Press.
9. Lindgren B.W.- *Statistical Theory*, Macmillan Publishing Co. Inc.
10. Montgomery D.C. – *Design and analysis of experiments*, John Wiley & Sons.
11. Mood A.M., Graybill F. and Bose D.C.- *Introduction to the theory of statistics*, McGraw Hill Publishing Co.
12. Murthy M.N. – *Sampling methods*, Indian Statistical Institute, Kolkata.
13. Paulos John A. (1990) *Innumeracy: Mathematical Illiteracy and its consequences*, Vintage Books Paperback.
14. Wayne Daniel (2007) *Biostatistics A foundation for Analysis in the health sciences*, Edition 7, Wiley- India edition.

SEMESTER – I

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

- A) Introduction to Bioorganic Chemistry (10)**
- 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 Waals interaction, charge transfer complexes, ionic bonding, Ion-dipole, 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: stereochemical aspect inhibition by penicillin
 - 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 (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, levo-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), T_m 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 (*Drosophilla*) 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

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

Ultrastructure and Organization of Eukaryotic Cell

1. Alberts Bruce (1985) *Molecular Biology of Cell*. Garland Pub.
2. Conn Eric, Stumpf Paul K., Bruuening George, Doi Roy H., (1987) *Outlines of Biochemistry Edition*, John Wiley and Sons, New Delhi.
3. De Robertis E. D. P. and De Robertis E. M. F. (1987), *Cellular and Molecular Biology* Lea and Febiger, Philadelphia.
4. Schlegel Hans G. (1995) *General Microbiology*, Edition 7, CUP, Cambridge.
5. Stanier R. Y., Adelberg E. A., Ingraham J. L., (1976) *General Microbiology*, 4th edition, Mac Millan Press, London.
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Development and Differentiation

1. Gibert Scott F. (2003). *Developmental Biology*. 7th Ed. Sinauer Associates Inc. Mass. USA.
2. Muller W.A. (1997) *Developmental Biology*, Springer – Verlag, New York, Inc.
3. Wolpert Lewis. (1998). *Principles of Development*. Oxford University Press. Oxford.

Chemical Composition of Living Systems

1. Berg Jeremy, Tymoczko John, Stryer Lubert (2001) *Biochemistry*. 6th Edition, W. H. Freeman, New York.
2. Conn Eric, Stumpf Paul K., Bruuening George, Doi Roy H., (1987) *Outlines of Biochemistry*. 5th Edition, John Wiley and Sons, New Delhi.
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4. Laskin A. I. and Lechevalier H. A. (1977), *CRC Handbook of Microbiology*, Vol. 1, Bacteria, CRC Press Ohio.
5. Metzler David E. (2001) *Biochemistry: The Chemical Reactions of Living Cells*, Volume 1 & 2, Academic Press California.
6. Nelson D. L. and Cox M. M. (2002) *Lehninger's Principles of Biochemistry*, Mac Millan Worth Pub. Co. New Delhi
7. Peberdy John F. (1980), *Developmental Microbiology*, Blackie, London.
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10. White David (2000) *Physiology and Biochemistry of Prokaryotes*. 2nd Ed. Oxford University Press, New York.

Communication and Coordination:

1. 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.
2. 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.
3. Toole 'O' George, H. B. Kaplan, R. Kolter, (2000) *Biofilm formation as microbial development* *Annual Review of Microbiology*, Vol. 54 49-79

SEMESTER – I

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.

SEMESTER – I

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_2PO_4 and K_2HPO_4 , acetic acid and sodium acetate, K_2HPO_4 and H_3PO_4
3. Chromatography: Separation of sugar and amino acids by paper and thin layer chromatography
4. Colorimetry and spectrophotometry: Estimation of sugar and total carbohydrate, estimation of protein by Lowry, Bradford and UV Spectrophotometry
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 sugar composition (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

SEMESTER – 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 chromatography, High Performance Liquid Chromatography
 2. Electrophoresis: Basic concepts, Gel Electrophoresis – agarose and acrylamide (native, denaturing and 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 Rotary Dispersion (ORD), Fluorescence spectroscopy, Infrared spectroscopy, FTIR
 5. Radiography: Tracer elements in Biology, Radioactive isotopes, Half life of isotopes, 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

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006) *Biochemistry*. 6th Edition. Freeman, New York.
2. Cotterill, R. M. J. (2002) *Biophysics: An Introduction*. John Wiley & Sons, England.
3. Drenth, J. (2007) *Principles of protein X-ray crystallography*. 3rd Ed. Springer, Germany.

4. Garrett, R. H. and Grisham, C. M. (2004) *Biochemistry*. 3rd Ed. Brooks/Cole, Publishing Company, California.
5. Keeler, J. (2002) *Understanding NMR Spectroscopy*. John Wiley & Sons, England.
6. Mount, D. W. (2001) *Bioinformatics: sequence and genome analysis*. Cold Spring Harbor Laboratory Press, New York.
7. Nölting, B. (2006) *Methods in modern biophysics*. Second Edition. Springer, Germany.
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9. Wilson Keith and Walker John (2005) *Principles and Techniques of Biochemistry and Molecular Biology*, 6th Ed. Cambridge University Press, New York.

Molecular Biophysics

1. Cavanagh John *et.al.* (1995) *Proteins NMR Spectroscopy: Principles and Practice*, Academic Press
2. Daune M. & W. J. Duffin (1999) *Molecular Biophysics: Structures in Motion*, Oxford University Press.
3. Nalting B. & B. Nalting (2003) *Methods in Modern Biophysics* Springer Verlag
4. Voit E. O. (2000) *Computational Analysis of Biochemical Systems* Cambridge University Press.

Other books:

1. Narayanan, P. (2000) *Essentials of Biophysics*. New Age International Publication, New Delhi
2. Stephenson, F. H. (2003) *Calculations in molecular biology and biotechnology: A guide to mathematics in the laboratory*. Academic Press, Elsevier Science, London. (For numerical problems in instrumentation)

SEMESTER – II

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.

Sociobiology, kin selection, evolutionary stability of cooperation, sociality and multicellularity in microorganisms, Game theory, Evolution and stability of sex, sexual selection, parasite theory of sex and sexual selection. Co-evolutionary strategies, host-parasite co-evolution, Neutral evolution and molecular clocks, phylogeny and molecular distances, Molecular evolution: origin of life, the origin of new genes and proteins. Evolution of life histories, ageing, evolutionary trade offs, r and k selection, Evolutionary origin of biochemical disorders: The case of insulin resistance.

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, flavonoid from plants, lectins, octopine, niptine, indole acetic acid.
2. Mycorrhiza: Host-fungus specificity, host fungus interactions, rhizosphere environment and recognition phenomenon, interaction of mycorrhizal fungi with non-host plants, functional capability.
3. Marine ecosystem: Environment of marine bacteria, bacterial growth in sea and its regulation by environmental conditions, modeling of growth and distribution of marine micro plankton, mechanism of dissolved, organic matter production (DOM), strategies of organic matter utilization and microbial utilization of organic matter in sea.

C) Wastewater Treatment:

(18)

1. Wastewater treatment system (unit process): Physical screening, flow equalization, mixing, flocculation, flotation, granular medium filtration, adsorption.
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 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 (Textile, dyestuff, dairy, paper and pulp manufacturing industries)

References:**Evolution:**

1. Ridley Mark (2004). *Evolution*. Blackwell Science Ltd.
2. Strickberger M. W. (2000). *Evolution*. Jones & Bartellette Publications.

Ecology

1. Macan, T. T. (1974). *Freshwater Ecology*. Longman Group Ltd., London,.
2. Meadows, P. S. and J. I. Campbell. (1978). *An introduction to Marine Science*. Blackie & Son Ltd., Glasgow.
3. Richards, B.N. (1987). *Microbiology of Terrestrial Ecosystems*. Longman Scientific & Technical, New York.

Waste Water Treatment:

1. Tchobanoglous G. and F. L. Burton. (1991). *Wastewater Engineering, Treatment, Disposal and Reuse*. 3rd Ed., Metcalf and Eddy (Eds). Tata Mac Graw Hill Publishing Co. Ltd. New Delhi.

SEMESTER – II

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 (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.
- 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 methanogenes
- 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:

1. Berg Jeremy, Tymoczko John, Stryer Lubert (2001) *Biochemistry* 4th Ed, W. H. Freeman, New York.
2. Conn Eric, Stumpf Paul K., Bruening George, Doi Roy H., (1987) *Outlines of Biochemistry* 5th Ed , John Wiley and Sons, New Delhi.
3. Dawes Edwin A. (1972) *Quantitative Problems in Biochemistry*, Churchill Livingstone, Edinburgh.
4. Hall D. D. and Rao K. K. (1996) *Photosynthesis* 5th Ed., Cambridge University Press.
5. Mandelstam Joel and McQuillen Kenneth (1976) *Biochemistry of Bacterial Growth*, Blackwell Scientific Publication London.
6. Metzler David E. (2001) *Biochemistry: The chemical Reactions of Living Cells*, Volume 1&2, Academic Press California.
7. Moat Albert G. and Foster John W. (1988) *Microbial Physiology* 2nd Ed. John Wiley and Sons New York.
8. Nelson D. L. and Cox M. M. (2005) *Lehninger's Principles of Biochemistry*, Fourth edition, W. H. Freeman & Co. New York.
9. Palmer Trevor (2001) *Enzymes: Biochemistry, Biotechnology and Clinical chemistry*, Horwood Pub. Co. Chinchester, England.
10. Segel Irvin H. (1997) *Biochemical Calculations* 2nd Ed., John Wiley and Sons, New York.
11. Voet Donald and Voet Judith G. (1995) *Biochemistry*, 2nd Ed.. John Wiley and sons New York.
12. White Abraham, Handler Philip, Smith Emil, Hill Rober, Lehman J. (1983) *Principles of Biochemistry*, Edition 6, Tata Mc-Graw Hill Companies, Inc.
13. White David (2000) *Physiology and Biochemistry of Prokaryotes*. 2nd Ed. Oxford University Press, New York.
14. Zubay Geoffrey (1998) *Biochemistry*, 4th Ed., W. C. Brown, New York.

SEMESTER – II

Practical course I – MB – 611: Ecology and Environmental Microbiology

1. Determination of DO, COD and BOD
2. Determination of TS and MLSS
3. Simulated Waste decomposition using aerobic microorganisms.
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

SEMESTER – II

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 K_m and V_m values of Invertase
5. Determination of K_m and V_m 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

SEMESTER – III

Theory course I - MB – 701: Immunology

- 1. Cytokines** (6)
 - a. Types and general properties of cytokines and chemokines, characteristics of cytokine receptors and antagonists
 - b. Source and effect of Tumor necrosis factors and Interferons
 - c. Role of IL-1 in immune activation and pyrogenesis
 - d. Immunoregulatory role of cytokines (in particular IL-4, IFN- γ and TNF- β)
 - e. Cytokines in therapy and disease, Super antigens and septic shock syndrome
 - f. Cytokine assays – immunological and functional assay systems

- 2. T-Cell Receptor:** (4)

Structure and types - $\alpha\beta$ and $\gamma\delta$ TCR, Diversity of TCR (gene organization and rearrangements), T cell accessory membrane molecules (CD and adhesion molecules), Role in immune activation: TCR-CD3 complex and signal transduction pathways

- 3. Regulation of Immune Response:** (6)
 - a. Negative regulation - Immunological tolerance, Mechanisms of tolerance induction, T cell mediated suppression of immune response
 - b. Regulation of immune responses by: antigen, antigen-antibody complexes, Network theory and its experimental evidence
 - c. Regulation of complement system – Classical and alternative pathway

- 4. Immune System Evolution:** (4)
 - a. Status of immune system in invertebrates and vertebrates with reference to diversity, complexity and efficiency of cells and molecules, anatomical organization,
 - b. Functional and structural evolution of immunoglobulin

- 5. Tumor Immunology:** (8)
 - a. Cellular transformations during neoplastic growth, Classification of tumors based on histological, physiological, biochemical and immunological properties, Tumors of lymphoid system (lymphoma, myeloma, Hodgkin's disease)
 - b. Escape mechanisms of tumor from host defense, Host immune response to tumor – Effector mechanisms, Immuno- surveillance theory
 - c. Diagnosis of tumors – biochemical and immunological tumor markers
 - d. Approaches in cancer immunotherapy: Immunomodulation (definition and concept), Immune adjuvant and tumor vaccine therapy, Biological Response Modifiers (BRMs) and their application in cancer therapy and in other diseases

- 6. Clinical Immunology** (16)
 - a. Immunity to infection – immune mechanisms to intracellular and extra-cellular infectious agents (with examples of bacterial, protozoan and parasitic infections, strategies for vaccine development)
 - b. Immunodeficiency disorders (pathophysiology, diagnosis and prognosis) –
 - i. Infective disorders: HIV-AIDS, Herpes infections
 - ii. Non-infective disorders: Phagocytic deficiencies, humoral deficiencies, T-cell deficiencies, and combined deficiencies, complement deficiencies

- c. Hypersensitivity disorders (pathophysiology, diagnosis and prognosis) – Asthma, Systemic Lupus Erythomatosus (SLE), Myasthenia gravis
- d. Therapeutic aspects in immunopathology – chemotherapy, strategies for immunotherapy (cytokine and vaccine therapy) and stem cell therapy

7. Experimental Immunology:

(4)

In vitro systems – kinetics of antigen antibody reactions, hemolytic plaque assay, ELISPOT assay, functional assays for phagocytosis

In vivo systems – Experimental animals in immunology research (Inbred animal strains, transgenic animals), Animal models for autoimmunity and AIDS

References:

1. Akihiko Yoshimura, Tetsuji Naka and Masato Kubo, (2007), *SOCS proteins, cytokine signaling and immune regulation*, Nature Reviews, Immunology, **7**:454-465
2. Austyn J. M. and Wood K. J. (1993) *Principles of Molecular and Cellular Immunology*, Oxford University Press,
3. Baron D. N. *Short Text book on Chemical Pathology*, ELBS, London.
4. Barret James D. (1983) *Text Book of Immunology* 4th edition, C. V. Mosby & Co. London.
5. Biotechnology by open learning series (BIOTOL), (1993), *Defense Mechanisms*, Butterworth and Heinemann Ltd., Oxford
6. Boyd William C. (1966) *Fundamentals of Immunology*, Interscience Publishers, NY.
7. Chatterji C. C. (1992) *Human Physiology* Vol. 1 &2, Medical Allied Agency, Calcutta.
8. David A. Hafler, (2007), *Cytokines and interventional immunology*, Nature Reviews, Immunology, **7**: 423
9. Garrison Fathman1 C., Luis Soares, Steven M. Chan1 & Paul J. Utz1, (2005), *An array of possibilities for the study of autoimmunity*, Nature Rev., **435**|2:605-611 Bendelac Albert, Paul B. Savage, and Luc Teyton, (2007), *The Biology of NKT Cells* Ann. Rev. Immunol. **25**:297–336
10. Guyton A. C. and Hall J. E. (1996) *Text Book of Medical Physiology*, Goel Book Agency, Bangalore.
11. Hughes Eric A. and Jorge E. Galan, (2002), *Immune Response to Salmonella: Location, Location, Location?*, Immunity, **16**: 325–328
12. Kuby J. (1996) *Immunology* 3rd Ed. W. H. Freeman & Co.
13. Michael C Carroll, (2004), *The complement system in regulation of adaptive immunity*, Nature Immunology **10**:981-986
14. Pathak S. S. and Palan V. (1997) *Immunology - Essential and Fundamental*, Pareen Publications Bombay.
15. Roitt Evan, Brostoff J. Male D. (1993) *Immunology* 6th Ed., Mosby & Co. London.
16. Roitt I. M. (1988) *Essentials of Immunology*, ELBS, London.
17. Roitt M. (1984) *Essentials of Immunology*, P. G. Publishers Pvt. Ltd., New Delhi.
18. Talwar G. P. (1983) *Handbook of Immunology*, Vikas Publishing Pvt. Ltd. New Delhi.
19. Zeev Pancer and Max D. Cooper, (2006), *The Evolution of Adaptive Immunity*, Ann. Rev. Immunol., **24**: 497–518
20. Stites D. P., Stobo J. D., Fudenberg H. H. and Wells J. V., (1982), *Basic and Clinical Immunology*, 4th Ed., Lange Medical Publications, Maruzen Asia Pvt. Ltd., Singapore

SEMESTER – III
Theory course II - MB – 702: Molecular Biology I

- 1. Genome organization: (12)**
1. Prokaryotic genome, Nucleoid, Eukaryotic genome, Organelle genome
 2. Structure of chromatin, nucleosome, chromatin organization and remodeling, higher order organization - chromosome, centromere, telomere
 3. Types of histones, histone modifications - Methylation, Acetylation, Phosphorylation and its effect on structure and function of chromatin
 4. DNA methylation and gene imprinting
 5. C value paradox and genome size, cot curves, repetitive and non-repetitive DNA sequence, Cot $\frac{1}{2}$ and Rot $\frac{1}{2}$ values,
 6. Pseudogenes, Gene families, Gene clusters, Super-families
- 2. DNA Replication: (10)**
- a. DNA replication in *E. coli*, Origin of replication, types of *E. coli* DNA polymerases, details of replication process, regulation of replication, connection of replication to cell cycle
 - b. Different models for replication of linear and circular DNA, replication features of single stranded phages,
 - c. Eukaryotic DNA replication, multiple replicons, eukaryotic DNA polymerases, ARS in yeast, Origin Recognition Complex (ORC), regulation of replication
- 3. DNA damage and repair: (06)**
- a. Different types of DNA damages,
 - b. Nucleotide excision repair, Base excision repair, mismatch repair, recombination repair, SOS operon, Double strand break repair, transcription coupled repair
- 4. Recombination: (06)**
- a. Homologous and site specific recombination
 - b. Models for homologous recombination: The Holliday model, Double strand break repair model
 - c. Proteins involved in recombination: RecA, B, C, D, Ruv A, B, C
 - d. Gene conversion
- 5. Mobile DNA elements: (06)**
- a. Transposable elements in bacteria, IS elements, composite transposons, replicative, non-replicative transposons, Mu transposition
 - b. Controlling elements in Tn A, Tn 5 and Tn 10 transposition
 - c. Retroviruses and retrotransposon, Ty elements in yeasts
 - d. SINES and LINES
- 6. Oncogenes and Cancer: (08)**
- a. Immortalization / transformation, metastasis, oncogenes and protooncogenes, Tumor suppressor genes
 - b. Transforming viruses, V-onc and C-onc genes, Ras pathway, Gene translocation, C-myc, Signal transduction, Src kinase, Tumor suppressors, RB and p53 protein, Apoptosis, DNA methylation and cancer, Molecular markers of tumor

References:

1. Benjamin Lewin. (2008) *Genes IX*, Jones and Bartelett Publishers Inc.
2. Bruce Alberts, Dennis Bray, Julian Lewis, Martin Raff, Keith Roberts, and James D. Watson (2004), *Molecular Biology of the Cell*, 4th Edition, Garland Publishing
3. Raff, Keith Roberts, Peter Walter, (2003) *Essential Cell Biology*, 2nd Edition, Garland Publishing
4. Watson James D., Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Lodwick (2004) *Molecular Biology of the Gene*, 5th Edition, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc.
5. Weaver R., (2007) *Molecular Biology*, 4th Edition, McGrew Hill Science.

SEMESTER – III
Theory course III - MB – 703: Virology

A. General Virology: (16)

1. Structure of viruses
 - a. Enveloped and non-enveloped viruses
 - b. Capsid symmetries – icosahedral, polyhedral and helical
 - c. Structural proteins – envelope proteins, matrix proteins and lipoproteins
 - d. Viral genomic organization and replication – types of nucleic acid DNA (double stranded and single-stranded), RNA (double stranded, single stranded – positive sense and negative sense)
 - e. Protein nucleic acid interactions and genome packaging
 - f. Virus related structures – viroids and prions

2. Cultivation of viruses: Growth of viruses in –
 - a. *In ovo*: using embryonated chicken eggs
 - b. *In vivo*: using experimental animals
 - c. *Ex vivo / In vitro* : using various cell cultures - primary and secondary cell lines, suspension cell cultures and monolayer cell cultures
 - d. Plants and plant cell cultures

3. Diagnostic and detection methods
 - a. Sampling techniques
 - b. Processing of samples – Enrichment and concentration
 - c. Direct methods of detection – light microscopy (inclusion bodies), electron microscopy and fluorescence microscopy
 - d. Immunodiagnosis, hemagglutination and hemagglutination-inhibition tests, Complement fixation, neutralization, Western blot, Radioactive Immuno precipitation Assay (RIPA), Flow cytometry and Immunohistochemistry.
 - e. Nucleic acid based diagnosis: Nucleic acid hybridization, polymerase chain reaction, microarray and nucleotide sequencing, LINE probe assay
 - f. Infectivity assay for animal and bacterial viruses - plaque method, pock counting, end point methods, LD₅₀, ID₅₀, EID₅₀, TCID₅₀
 - g. Infectivity assays of plant viruses

4. ICTV nomenclature and classification of viruses (as per 9th Edition, 2008)

B. Viral Diseases in Animals: (12)

1. General characters and genomic structure, pathophysiology and epidemiology for the diseases caused by:
 - a. Herpes Viruses,
 - b. Simian Virus 40
 - c. Newcastle (Ranikhet) disease and Marek disease in poultry
 - d. Rinderpest disease in cattle

2. a. Viral Vaccines: Conventional vaccines – killed and attenuated, Modern vaccines – DNA vaccines, recombinant DNA/protein vaccines, subunits vaccines, peptide vaccines, anti-idiotypic vaccines, edible vaccines, immunomodulators (cytokines), adjuvants to increase immunogenicity of vaccines

- b. Antivirals: Interferons, designing and screening for antivirals, mechanisms of action, antiretrovirals — mechanism of action and drug resistance
- 3. Oncogenic viruses: Virus induced cell transformation and oncogenesis, Mechanism of cell transformation by RNA viruses and by DNA tumor viruses, Retrovirus mediated oncogenesis

C. Viral Disease in Plants: (12)

- 1. Effects of viruses on plants: Appearance of infected plants, histological, physiological and cytological changes in infected plants
- 2. Behavior of viruses in plants: Early stages of infection, biochemistry of virus replication, cellular sites of virus replication and assembly, release and translocation of virus particles in tissues
- 3. Methods for detection of plant viruses:
 - a. In seeds, seed stocks and diseased plants
 - b. indicator plants
 - c. Antigen based methods
 - d. Histopathological methods
- 4. Transmission of plant viruses:
 - a. Through vectors - insects, nematodes and fungi
 - b. Without vectors - contact, seed and pollens
- 5. Prevention of crop losses due to virus infection - virus free planting material, vector control, disease forecasting
- 6. Life cycles of plant viruses – TMV, Cauliflower mosaic virus

D. Bacteriophages: (8)

- 1. Morphology, genome organization and life cycles of – T (odd and even), Lambda and M13 phages
- 2. Phage therapy for control of bacterial poultry diseases

References:

A. General Virology

- 1. Edward K. Wagner, Martinez J. Hewlett, (2004), *Basic Virology*, Blackwell Publishing
- 2. 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, Chapters 3-13
- 3. 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.
- 4. International Congress on Taxonomy of Viruses:
<http://www.ncbi.nlm.nih.gov/ICTV>
- 5. 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
- 6. Luria S. E. et.al. (1978) *General virology*, 3rd Ed, New York. John Wiley and Sons.
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B. Animal Viruses

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5. Murphy Frederick A. E., Paul J. Gibbs, Marian C. Horzinek, Michael J. Studdert, (1999), *Veterinary Virology*, Academic Press
6. Plotkin Stanley A., Walter A. Orenstein, (2003), *Vaccines*, Elsevier Health Sciences
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8. Stephenson John R. (Editor), Alan Warnes, (1998), *Diagnostic Virology Protocols: Methods in Molecular Medicine*, Humana Press
9. Tying. Stephen K. (2004), *Antiviral Agents, Vaccines, and Immunotherapies*, Marcel Dekker

C. Plant viruses

1. Davis and Dulbacco *Medical Microbiology*
2. Gibbs Adrian & Bryan Harrison () *Plant Virology -The Principles*. Edward Arnold Press
3. Prusiner S. B. (1995) *The Prion Diseases*, *Scientific American* (1):48-57
4. Reisner D. & Gross H.J. (1985) *Viroids* *Ann. Rev. Biochem.* **54**:531-64
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6. Stephens B. and Compons R. W. (1998) *Assembly of animal viruses at the cellular membrane* *Ann. Rev. Microbiol.* **42**:489-519

D. Bacterial viruses

1. Douglas John, (1975), *Bacteriophages*, Chapman and Hall, London
2. Hendrix R. W., (2002), *Bacteriophage λ and its relative*, Uldis N. Streips and Ronald E. Yasbin, Editors, *Modern Microbial Genetics*, 2nd Ed., Wiley-Liss Inc, 127-143
3. 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, 85-126

SEMESTER – III

Practical course I - MB – 711: Microbial Technology

1. Bioassay and Chemical estimation of penicillin
2. Preparation of bioinoculants – phosphate solubilizers, mycoinsecticides (*Trichoderma*) and cell count determination on time scale
3. Preparation of enzyme immobilized columns for biotransformation –e.g. yeast cells immobilized in calcium alginate beads
4. Parameter testing for immobilized enzyme columns:
 - a. Comparative enzyme activity of free cells and immobilized cells
 - b. Effect of gel concentration on enzyme activity
 - c. Effect of cell concentration on enzyme activity
5. Studies on laboratory scale production of exopolysaccharide (Pullulan gum) and microbial emulsifiers – using suitable production strains (obtained from culture collections), Media optimization for large scale production (effect of medium composition on any one of the products)
6. Biosorption of dyes or metals using dead biomass. *Aspergillus niger* or brewer's yeast cells could be grown in liquid media, harvested and killed by autoclaving. Dried biomass to be used for biosorption (both the organisms are suitable for adsorbing Congo Red).
7. Estimation of antimicrobial activity using standard guidelines (NCCLS/CLSA)
8. Extraction and estimation of bioactive (antimicrobial) principles from plants; and activity fractionation.
9. Preparation and maintenance of plant callus culture, Differentiation of callus culture in to shoot / root.
10. Study of plant virus diseases: Collecting data and samples (preparation of herbaria), infectivity assays in indicator plants

References:

1. Christian Barnett, Alan Smith, Bernard Scanlon and Cleanthes J. Israilide, (1998), *Pullulan production by Aureobasidium pullulans growing on hydrolysed potato starch waste*, Elsevier Science Ltd.
2. Stanbury P.F., Whittaker A., Hall S.J., Principles of Fermentation Technology 2nd Edition.
3. Wilson & Walker, (1995) Practical Biochemistry, Principles & Techniques.

SEMESTER – III

Practical course II - MB – 712: Molecular Biology and Immunology

Molecular Biology

1. Plasmid DNA extraction and agarose gel electrophoresis. Determination of molecular weight of plasmid DNA.
2. PCR amplification of desired gene
3. Restriction digestion and ligation of DNA, Endonuclease mapping of DNA
4. Preparation of competent cells and transformation of plasmid DNA in *E. coli*.
5. Curing of plasmid using agents such as Ethidium bromide, Acridine orange, Plumbagin and Mitomycin C.

Immunology

1. Precipitation reactions of antigen-antibody: Immunelectrophoresis –rocket immunelectrophoresis, Single and Double diffusion techniques
2. Agglutination techniques: Preparation of O and H antigen of *Salmonella* and its testing using known antisera, Titre determination of isoantibodies to human blood group antigens; demonstration of prozone and postzone phenomenon
3. Separation of lymphocytes, Lymphocyte culture and detecting proliferation on mitogenic stimulus
4. Preparation of primary cell line from chick embryo
5. Animal inoculation technique by different routes: Subcutaneous, intra dermal, intra muscular, intra venous, intra cerebral etc.
6. Egg inoculation technique by various routes - embryo, yolk sac, allantoic fluid, amniotic cavity, chorioallantoic membrane

References:

1. Plummer David T., (1988), An introduction to practical biochemistry, 3rd Ed., Tata McGraw-Hill Publishing Co. Ltd. New Delhi, 109-121
2. Talwar G. P. (1983) *Handbook of Immunology*, Vikas Publishing Pvt. Ltd. New Delhi
3. Sambrook J, Fritsch E F, Maniatis T (1989) *Molecular cloning – a laboratory Manual* 2nd ed. Cold spring harbour NY: cold spring harbour laboratory press.
4. Ausbel F. M. and Brent R., (1994), *Current protocols in Molecular biology*, John Wiley & sons Inc, NY
5. Ausbel F. M. and Brent R., (), *Short protocols in Molecular biology*, John Wiley & sons Inc, NY

SEMESTER – IV

Theory course I - MB – 801: Pharmaceutical and Medical Microbiology

A] Pharmaceutical Microbiology

(The focus of the following topics should preferentially be the drugs against micro-organisms and from micro-organisms)

1. Drug discovery (12)

- a. Historical perspective – Paul Ehrlich’s postulates, Case studies of development of drugs e. g. sulpha drugs, arsenicals
- b. Current approaches to drug discovery: Rational Drug design, receptor / target concept in drug designing, Introduction to pharmacogenomics, Combinatorial chemistry, High Throughput Screening
- c. Phases of drug discovery: Bioprospecting, Principles of Extraction, Purification and Characterization of bioactive molecules from natural resources, Lead discovery, Lead compound optimization, Candidate drug selection
- d. Preclinical development:
 - i. Safety profile of drugs (Pyrogenicity, Toxicity –hepato, - nephro, -cardio and -neurotoxicity)
 - ii. Toxicological evaluation of drug: LD₅₀, Acute, subacute and chronic toxicity
 - iii. Mutagenicity (Ames test, micronucleus test), Carcinogenicity and Teratogenicity
- e. Drug interactions, Drug metabolism – activation / inhibition of drug *in vivo*, adverse drug reactions

2. Clinical development of biologicals: (8)

- a. Regulatory authorities for introduction of medicines in market – Role of Food and Drug Administration, FDA guidelines for drugs / biologicals, Validation (GMP, GLP, GCP, etc.)
- b. Clinical studies: Phase I, phase II, phase III and phase IV of clinical trials – Objectives, Conduct of trials, Outcome of trials
- c. Delivery systems – formulations, targeted drug delivery, Sustained release drugs
- d. Drug distribution in body, bio-availability and pharmacokinetic studies

3. Development of antimicrobial agents: (12)

- a. Screening and development strategies for new antimicrobial agents with respect their mode of action and studying the mechanism of resistance, based on examples of established drugs acting on bacterial cell wall, cell membrane, nucleic acid and protein metabolism.
- b. Bioassay of antibacterial agents in liquid media and in agar media using standard guidelines (e.g. National Committee for Clinical Laboratory Standards (NCCLS) / Clinical and Laboratory Standards Institute (CLSI)), Factors affecting bioassay, Laboratory methods to assess activity of antimicrobial combinations (antagonism, synergism and additive effect)
- c. Methodologies for testing of antimycobacterial, antifungal, antiparasitic and antiviral drugs (*in vivo* and *in vitro* infectivity models).

B] Medical Microbiology

(16)

Mechanisms of Bacterial Virulence:

1. A step wise process of infection – Crossing physical, chemical and biological barriers, Colonization, Association, Adhesion and Invasion of host tissue and toxigenesis. with details account of virulence factors – Adhesins (pili, capsule, hemagglutinins), Invasins (Fibrinolysins, hyaluronidase, hemolysins, hypal extensions), Evasins (catalase, coagulase, Siderophores, Leucocidins, Kinins), Toxins (diphtheria, cholera, tetanus toxins and endotoxins of Gram negative bacteria – mode of action and *in vivo* and *in vitro* assay systems).
2. Mechanisms of bacterial resistance to host cellular (phagocytosis) and humoral defenses
3. Molecular basis of bacterial pathogenicity – cytoskeletal modulation of host cell, virulence genes and pathogenicity islands

References:

Pharmaceutical Microbiology

1. Agarwal S. S. and Paridhavi M., (2007), *Herbal Drug Technology*, Universities Press (India) Pvt. Ltd
2. Altreuter D., and D S. Clark, (1999), *Combinatorial Biocatalysis: Taking the Lead From Nature*, Curr. Opin. Biotechnol. **10**, 130.
3. Bentley's Textbook of Pharmaceutics, Editor E. A. Rawlins, 8th Ed. (2002), BAilliere Tindall, London
4. Burn J. H. (1957) *Principles of Therapeutics*, Blackwell Scientific Pub. O. Ltd. Oxford.
5. Chatwal G. P. (2003) *Biopharmaceutics and Pharmacokinetics*, Himalaya Publishing House, Mumbai.
6. Chorghade Mukund S., (2006), *Drug discovery and development Volume I: Drug discovery*, Wiley-Interscience, John Wiley and Sons Inc. USA.
7. Committee for the Purpose of Control and Supervision on Experiments on Animals (CPCSEA), www.cpcsea.com
8. Dale Maureen M, John C. Foreman and Tai-Pang D. Fan, (1004), *Text book of Immunopathology*, 3rd Ed., Blackwell Scientific Publication, London
9. Dewick Paul M., (2002), *Medicinal natural products: A biosynthetic approach*, 2nd Ed., John Wiley and Sons
10. Gale E. F., Cundliffe E., Reynolds P. E., Richmond M. H. and Waring M. J., (1972), *The molecular basis of antibiotic action*, John Wiley and Sons, London
11. Goldstein A., Aronow L., and Kalman S. M. (1969) *Principles of Drug Action, The Basis of Pharmacology*, Harper international edition New York.
12. Graly John O. and Pieter H. Joubert, (1997), *Handbook of Phase I/ II clinical drug trials*, CRC Press
13. Iyengar M. A. (1974) *Pharmacology of Powdered Crude Drugs*, Manipal
14. Kavanagh Frederick, (1963), *Analytical Microbiology Volume I and II*, Academic Press, London
15. Kokate C. K., Purohit A. P., Gokhale A. B. (2000) *Pharmacology*, 4th Ed., Nirali Prakashan.
16. Lorian.V., (1986), *Antibiotics in laboratory medicine*, 2nd Ed, Williams & Wilkins Publication
17. Mannfred A. Holliger, (2008), *Introduction to pharmacology*, 3rd Ed., CRC Press

18. Maron Dorothy M. and Bruce N. Ames, (1983), *Revised methods for the Salmonella mutagenicity test*, Mutation Research, **113**:173-215
19. Micheles P. S., Y. L. Khmel'nitsley, J. S. Dordick and D. S. Clark, (1998), *Combinatorial Biocatalysis, A Natural Approach to Drug Discovery*, Trends in Biotechnol. **16**, 197.
20. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). *Methods for dilution antimicrobial susceptibility testing for bacteria that grows aerobically. Approved Standards M7-A4*. Villanova, PA: NCCLS, 1997.
21. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). *Performance standards for antimicrobial susceptibility testing; 12th information supplement (M100-S1)*. Villanova, PA; NCCLS: 2002
22. Osol Arther (1975) *Remington's Pharmaceutical Sciences*, 15th Ed., Mack Pub. Co., Pennsylvania.
23. Satoskar R. S. & S. D. Bhandarkar (1991) *Pharmacology and Pharmacotherapeutics*, 12th Ed., Vol. 1 & 2, Popular Prakashan, Mumbai.
24. Sylvie E. Blondelle, Enrique Pe Rez-Paya, And Richard A. Houghten, (1996), *Synthetic Combinatorial Libraries: Novel Discovery Strategy for Identification of Antimicrobial Agents*, Antimicrobial Agents and Chemotherapy, 1067–1071
25. Walsh Gary, (2003), *Biopharmaceuticals Biochemistry And Biotechnology*, 2nd Ed., John Wiley & Sons Ltd, England
26. Vyas S. P and Dixit V. R. (2002), *Pharmaceutical Biotechnology*, CBS Publishers and Distributors, New Delhi

Medical Microbiology

1. Unsworth K. E. and David W. Holden, (2000), *Identification and analysis of bacterial virulence genes in vivo*, Phil. Trans. R. Soc. London B. **355**, 613-622
2. Woods D. E., (2002), *The use of animal infection models to study the pathogenesis of melioidosis and glanders*, Trends Microbiol, **10(11)**:483-5
3. Eduardo A. Groisman and Howard Ochman, (1994), *How to become a pathogen*, Trends in Microbiology, **2(8)**:289-294
4. Carpenter Philip L., (1975), *Saunders International Edition - Immunology and Serology*, W. B. Saunders and Co., London
5. Schlessinger David, Editor, *Mechanism of Microbial Virulence*, in Microbiology – 1979, American Society for Microbiology, Washington D. C., 79-230
6. Schlessinger David, Editor, *Biochemical Genetics of Pathogenecity*, in Microbiology – 1979, American Society for Microbiology, Washington D. C., 79-230
7. Mark J. Pallen & Brendan W. Wren, (2007), *Bacterial pathogenomics*, Nature Rev. **449|18**: 835-842
8. Hughes Eric A. and Jorge E. Galan, (2002), *Immune Response to Salmonella: Location, Location, Location?*, Immunity, **16**: 325–328
9. Bhavsar Amit P., Julian A. Guttman and B. Brett Finlay, (2007), *Manipulation of host-cell pathways by bacterial pathogens*, Nature Rev **449|18**:827-834
10. David N. Fredricks and David A. Relman, (1996), *Sequence-Based Identification of Microbial Pathogens: a Reconsideration of Koch's Postulates*, Clinical Microbiology Reviews, 18–33

SEMESTER – IV

Theory course II - MB – 802: Molecular Biology II

- 1. Transcription (12)**
 - a. Structure of bacterial RNA polymerase, Typical bacterial promoter, Role of sigma factor, Transcription - initiation, elongation and termination events (Rho dependent, Rho independent termination), DNA foot printing, Gel retardation assay
 - b. Eukaryotic RNA polymerases I, II and III and their promoters, Enhancers, TATA box Binding Protein (TBP)
 - c. Processing of RNA: RNA splicing- group I, group II introns, t-RNA processing, RNA editing, Capping of mRNA and polyadenylation
 - d. Eukaryotic transcription regulation based on mRNA stability and localization, non-coding RNAs and their role
 - e. Regulatory RNA: antisense RNAs, micro RNAs, RNA interference, attenuation

- 2. Genetic code and Translation (12)**
 - a. Historical approach, deciphering the genetic code, code alignment, characteristics of genetic code, altered code in mitochondria, codon usage
 - b. t-RNA: Structure, modified bases in t-RNA, amino acyl t-RNA synthetase
 - c. Ribosomal structural components, comparison of eukaryotic and prokaryotic ribosomes, active centers of ribosome, rRNA synthesis and its regulation
 - d. Translation:
 - i. Translation process in prokaryotes and eukaryotes.- initiation, elongation, termination of translation
 - ii. Co-translational / post-translational modifications, Molecular chaperons
 - iii. Protein splicing - inteins, exteins
 - iv. Cytosolic protein degradation

- 3. Recombinant DNA Technology (10)**
 - a. Enzymes used in recombinant DNA technology, shot gun cloning, gene library, cDNA Cloning
 - b. Preparation of recombinant DNA and its transfer to appropriate host (bacteria, yeast, plants, and animals), characterization, selection and screening of recombinants, Phage display systems, Heterologous gene expression
 - c. Vectors: Plasmids, cosmid, phages- lambda vectors, single strand vectors, Expression vectors, high capacity vectors: PAC, BAC and YAC

- 4. Techniques used in RDT: (10)**
 - a. Southern blot, Northern and Western hybridization technique - use of radioactive and non-radioactive nucleotides for probe preparation and detection of hybrids, PCR, RT-PCR, Real time PCR and its applications, DNA microarrays and their use in genomics
 - b. Sequencing techniques: Maxam and Gilbert method, Sanger's di-deoxy method and modifications, Automated sequencers, Pyrosequencing and recently developed sequencing methods.
 - c. Protein sequencing

- 5. Genome project: (04)**
 - a. Concept and meaning of genome projects and their applications.
 - b. Gene annotation.

References:

1. Benjamin Lewin. (2008) *Genes IX*, Jones and Bartlett Publishers Inc.
2. James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Loswick (2004) *Molecular Biology of the Gene*, 5th Edition, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc.
3. Weaver R., (2007) *Molecular Biology*, 4th Edition, McGraw Hill Science.
4. Sandy Primrose, Richard Twyman, Bob Old (2001), *Principles of Gene Manipulation*, 6th Edition, Blackwell Science Ltd.
5. Brown T., (2007) *Genome 3*, 3rd Edition, Garland Science
6. Strachan T. and Read A., (2004), *Human Molecular Genetics*, 3rd Edition, Garland Science.
7. Wink Michael, Ed., *An introduction to molecular biotechnology*, Wiley-VCH Publications

SEMESTER – IV

Theory course III - MB – 803: Microbial Technology

I] Principles of Bioengineering: (20)

1. Bioreactor design and operation:

- a. Designing of bioreactors - Design aspects CSTRs: The dimensional ratios of the outer shell, and the operational aspects such as working volume, baffles and impellers. The configuration (placement) of impellers in a vessel and the different types of impellers (types of turbines and propellers, and their combinations)
- b. Immobilized cell reactors and air-lift reactors – Design and operation.

2. Aeration and agitation:

- a. Aeration - Theory of oxygen transfer in bubble aeration, Oxygen transfer kinetics (Oxygen Uptake Rate –OUR; Oxygen Transfer Rate OTR; C_{crit}), determination of K_{La} .
- b. Agitation - Functions of agitation. Flow patterns with different types of impellers.
- c. Fermentation broth rheology and power requirements for agitation – Concept of Newtonian and non-Newtonian fluids, effect of broth rheology on heat, nutrient and oxygen transfer, Reynold's number, Power number, Aeration number < working out examples using different softwares

3. Monitoring of process variables:

Use of various types of sensors and biosensors for monitoring environmental parameters (pressure, pH, temperature, DO and DCO_2), Basic principles of operation, types of biosensors

4. a) Growth and product formation during fermentation:

Concept of primary (growth associated) and secondary (growth non-associated) metabolites and their control, Kinetics of growth and product formation (growth rate, yield coefficient, efficiency etc.)

b) Operational modes of bioreactors:

Batch, Fed-batch and Continuous processes: Applications, advantages and limitations of each type.

5. Effect of type of growth on fermentation:

The type of growth (mycelial pellet form, mycelial filamentous form, free cell, cells producing exopolysaccharides) affects mass transfer of nutrients, oxygen and heat; as also cell proliferation can be affected by shearing of cells. At least one example of each type may be explained to show these effects in any suitable fermentation.

II] Processes (20)

Upstream, Fermentation and Downstream Processing for the following:

1. Antibiotics (Rifamycin)
2. Microbial enzymes (Chitinase, Glucose Oxidase, Lipase)
3. Exopolysaccharides (Pullulan)
4. Use of immobilized cells / enzymes to produce protease
5. Use of fungi in industry including food industry, biosensors and fuel cells (Architecture of the fungal cell: cell wall, membranes and cytoskeleton)

6. Use of fungi in agriculture and environmental applications: Biofertilizers, Bioremediation and Biological control.
7. Animal cell culture technology to produce recombinant vaccines

III] Principles of Validation Process / Method Validation: (4)

- a) The concept of ISO Certification.
- b) Preparation of SOPs
- c) Validation protocols for methods in Quality Control
- d) Process validation

The above should be discussed within WHO Norms.

Exercises on preparation of SOPs, operation and validation for analytical methods

IV] Intellectual Property Rights (IPR): (4)

Basic concepts of IPR

Introduction to forms of IPR – Patents and Designs

References:

1. Bhate and Pongashe, *Patent*, Bhate Prakashan , Pune
2. *Bioreactor Design and Product Yield* (1992), BIOTOL series, Butterworths Heinemann.
3. Doran Pauline (1995) *Bioprocess Engineering Principles*, Academic Press.
4. Klegerman, M.E and Groves M.J. (1992) *Pharmaceutical Biotechnology: Fundamentals and Essentials*. Interpharm Press Ltd. Buffalo Grove IL
5. Komamine A., Misawa M and Dicosmo F Eds. (1991), *Plant cell culture in Japan*. CMC Co. Ltd, Tokyo
6. Lydersen B., N. a. D' Elia and K. M. Nelson (Eds.) (1993) *Bioprocess Engineering: Syatems, Equipment and Facilities*, John Wiley and Sons Inc.
7. Marris. P., Scragg, A.H., Standford, A and Fowlew M.W eds. (1986) *Secondary metabolism in plant tissue cultures*. Cambridge Univ. Press, Cambridge
8. Moo-Young M. ed. (1985) *Comprehensive Biotechnology* Vol: III & IV, Pergamon Press. N.Y
9. *Operational Modes of Bioreactors*, (1992) BIOTOL series, Butterworths Heinemann.
10. Peppler H. J. and D. Perlman (1970) *Microbial Technology* Volume 1 and 2, Academic Press New York.
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12. Ratledge C and Kristiansen B eds. (2001) *Basic Biotechnology* 2nd Ed. Cambridge Univ. Press. Cambridge
13. Reed G. Ed. *Prescott and Dunn's Industrial Microbiology* . 4th Ed., CBS Pub. New Delhi.
14. Shuichi and Aiba. *Biochemical Engineering*. Academic Press. 1982.
15. Van Damme E. J. (1984) *Biotechnology of Industrial Antibiotics*, Marcel Dekker Inc. New York.
16. Wetter L.R and Canstabel eds. (1982) *Plant Tissue Culture methods*. Natl. Res. Council, Canada
17. Wiseman A.(1985) *Topics in Enzyme and Fermentation - Biotechnology*, Vol. 1 and 2, John Wiley and Sons, New York.
- 18.

SEMESTER – IV
Practical course I - MB – 811: Research Methodology I
(Dissertation)

Scientific communication: Scientific writing (The objective of this practical will be preparing a research paper based on results of the dissertation work. The data generated through the dissertation work of student should be used for this exercise. All the following aspects can be included in the final report and presentation of the dissertation work):

1. Title and abstract for a given text.
2. Choosing and indexing key words from a given paper
3. Writing the paper based on a given set of instructions to authors. (Any refereed journal may be used for sample ‘Instructions to Authors’)
4. Writing a newspaper report / popular article of a latest research paper.
5. Writing a pedagogical (academic) article on a scientific theme
6. Critically comment on a manuscript
7. Drawing appropriate figures on given data, writing footnotes to figures and tables
8. Preparation of display material (such as scientific posters)
9. Photomicrography, taking photographs of experimental results
10. Making OHP transparencies, Scanning pictures, Making Power Point slide shows

SEMESTER – IV
Practical course II - MB – 812: Research Methodology
(Dissertation)

Dissertation carried out by the students should exercise the following steps in a systematic manner, under the supervision of practical-in-charge / project coordinator

1. Literature review (and choosing a suitable topic)
2. Experiment planning
3. Experimentation, with the use of contemporary methods and standard protocols
4. Representation of and calculations for data obtained
5. Interpretation of data with the use of statistical tools (if required)
6. Writing monthly progress reports / synopsis / interim reports
7. Writing a Masters thesis
8. Presenting the thesis in an ‘Open Defense’