University of Rajasthan
Jaipur

SYLLABUS

M.Sc. Microbiology

(Semester Scheme)

I & II SEMESTER -2020-21

III & IV SEMESTER -2021-22

Dy. Registrar (Acad.)
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MAX MARKS -100 **PASS MARKS- 36**

THEORY PAPER DURATION: 3 HRS. **PRACTICAL: 6 HRS.**

First Semester with laboratory work

S.No.	Subject code	Course title	Course category	Credit
1	MBC 701	General Microbiology	CCC	4
2	MBC 702	Techniques in Microbiology	CCC	4
3.	MBC 703	Microbial Biochemistry	CCC	4
4.	MBC 711	Lab.(Based on MBC 701, MBC 702 &MBC 703)		6
5.	MBE 701	Molecular Biology	ECC	4
6.	MBE 702	Biostatistics	ECC	4
7.	MBE 703	Bioinstrumentation	ECC	4
8.	MBE 712	Lab. (Based on electives only)		6

Second Semester with laboratory work **Session 2019-2020**

S.No.	Subject code	Course title	Course category	Credit
1	MBC 801	Bacteriology	CCC	4
2.	MBC 802	Microbial Metabolism &Physiology	CCC	4
3.	MBC 803	Medical Microbiology	CCC	4
4.	MBC 811	Lab.(Based on MBC 801,MBC 802 &MBC 803)		6
5.	MBE 801	Food Microbiology	ECC	4
6.	MBE 802	Environmental Microbiology	ECC	4
7.	MBE 803	Dairy Microbiology	ECC	4
8.	MBE 812	Lab.(based on Electives only)		6

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(Academic)
University of Rajasthan
JAIPUR

Third Semester with laboratory work

S.No.	Subject code	Course title	Course category	Credit
1	MBC 901	Virology	CCC	4
2.	MBC 902	Microbial Genetics	CCC	4
3.	MBC 903	Computational Biology	CCC	4
4.	MBC 911	Lab.(Based on MBC 901,MBC 902 &MBC 903		6
5.	MBE 901	Phycology &Mycology	ECC	4
6.	MBE 902	Genetic Engineering	ECC	4
7.	MBE 903	Dissertation in Microbiology	ECC	4
8.	MBE 912	Lab.(based on Electives only)		6

Fourth semester with Laboratory work

Session 2020-2021

S.No.	Subject code	Course title	Course category	Credit
1	MBC 1001	Immunology	CCC	4
2	MBC 1002	Microbial Ecology	CCC	4
3.	MBC 1003	Industrial Microbiology	CCC	4
4.	MBC 1011	Lab.(Based on MBC 1001, MBC 1002 &MBC 1003)		6
5.	MBE 1001	Genomics & Proteomics	ECC	4
6.	MBE 1002	Agriculture Microbiology	ECC	4
7.	MBE 1003	Clinical and Pharmaceutical Microbiology	ECC	4
8.	MBE 1012	Lab. (Based on electives only)		6

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SCHEME OF EXAMINATION MICROBIOLOGY

- As per discussion of academic council, the student will require to earn 120 credits for PG course out of total 144 credits.
- In theory 15 hrs of teaching is equal to one credit.
- In practical 45 hrs of laboratory work is equal to 2 credits.
- Each Semester of PG course shall have 36 credits.
- Each Semester will have continuous assessment which will include internal assessment in theory and practical by internal examination /seminar/oral examination- Viva voce etc. and the maximum marks will be 20.
- Each theory paper shall carry 100marks. It will be of 3 (three) hrs duration.
- Part A of question paper shall contain 10 (Ten) very short answer type questions covering the entire syllabus. Each question will carry 2 (two) marks i.e. part A will be of total 20 marks.
- In part B, there will be 4 questions, one per unit with internal choice. Each question will carry 20 marks i.e. total of 80 marks.
- Each practical examination will be of 6 hrs duration and will involve laboratory experiments / exercises and Viva –voce examination.

SCHEME OF PRACTICAL EXAMINATION

For all Semesters the scheme of practical examination is as follows:

MM: 100 **Duration 6 hrs**

1.	Major Exercise	16 Marks
2.	Major Exercise	15 Marks
3.	Major Exercise	15 Marks
4.	Spotting	24 Marks
5.	Seminar	10 Marks
6.	Record	10 Marks
7.	Viva- voce	10 Marks
	Total	**100 Marks**

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University of Rajasthan
JAIPUR

Syllabus M.Sc. Microbiology

Semester I

MBC 701: General Microbiology

Max. Marks -100

Unit I

Discovery of microbial world : History of Microbiology and contributions of Anton Von Leeuwenhoek, Joseph Lister, Paul Ehrlich, Edward Jenner, Louis Pasteur, Robert Koch, Martinus Beijerinck, Sergei Winogradsky, Alexander Fleming, Selman Waksman; Spontaneous generation controversy; Current thoughts on microbial evolution including the origin of life; Scope and relevance of microbiology.

Unit –II

System of Classification- Binomial classification, Whittaker's five kingdom scheme, Three domain system of classification and eight kingdom system of classification, Bergey's system of bacterial classification, Characteristics & Classification of Archaebacteria & Cynobacteria, Difference between prokaryotic and eukaryotic microorganisms.

Unit –III

General characteristics: Acellular microorganisms (Viruses, viroids & Prions), Nomenclature and classification of viruses.

Unit-IV

Cellular microorganisms with emphasis on distribution, occurrence, morphology, mode of reproduction and economic importance.

Bacteria: *Cyanobacteria, Spirochaetes, Rhizobium, Nitrosomanas, Clostridium, Lactobacillus, Streptococcus & Staphyococcus.*

Fungi: *Sacchromyces cerevisae, Dictyostelium discodium, Penicillum, Aspergillus & Candida albicans.*

Algae: *Diatoms & Dinoflagellates.*

Protozoa: *Entamoeba, Toxoplasma, Plasmodium, Trypanosoma,* Leishmania & *Giardia.*

Practicals:

1. Bacterial smear preparation.
2. Identification of various bacteria: Simple staining.
3. Identification of various bacteria: Gram staining.
4. Identification of various algae.
5. Identification of various fungi: Lactophenol -cotton blue & Acid Fuschin.
6. Identification of various protozoans - Free living.
7. Identification of various protozoans: Parasitic.
8. Identification of Cyanobacteria.
9. Culture & Identification of yeast.
10. Permanent slides: From bacteria, fungi, algae and protozoans.

Note:
(a) Slides to be prepared for submission wherever possible.
(b) Photographs may be supplemented if slides are not available.

Suggested Books:

1. Aneja K.R., Jain P. and Aneja R., 2008, A text book of basic and applied microbiology, New Age Int. Publications. New Delhi.
2. Atlas R.M., 1995, Principles of Microbiology Mosby publishers, St. Louis.
3. Balows A., Truper, H. G., Dworkin M., Harder, W. and Schleifer, K. H., 1992, The Prokaryotes. A handbook on the biology of bacteria: ecophysiology, isolation, identification, applications. Volumes I-IV, Springer-Verlag, New York.
4. Berg J.M., Tymoczko J.L. and Stryer L., 2007, Biochemistry Edition W.H. Freeman and Company, New York.
5. Holt J.G, and Krieg N.R., 1984-1989, Bergey's Manual of Systematic Bacteriology 1st Edition (Volumes 1-4) Williams and Wilkins Co Baltimore, Springer.
6. Holt J.G., and Krieg N.R., Sneath P.H.A., Staley J.T. and Williams J.T., 1994, Bergey's Manual Determinative Bacteriology 9th Edition, Williams and Wilkins Co Baltimore, Springer.
7. Logan, A. and Logan N.A., 1994, Bacterial Systematics, Wiley- Blackwell.
8. Nelson D. and Cox M.M., 2009, Principles of Biochemistry Edition W.H. Freeman and Company, New York.
9. Prescott L.M., Harley J.P. and Klein D.A., 2007, Microbiology 7th Edition, Mc Grow Hill.

10. Talaro K.P. and Talaro A., 2006, Foundations in Microbiology, Mc Graw Hill Publications.
11. Tortora G.J., Funke B.R. and Benjamin C.L.C., 2008, Microbiology: An Introduction, Cummings Publishing Company.
12. Wilson K. and Walker J., 2008, Principles and Technique of Biochemistry and Molecular Biology. 6th Edition Cambridge University Press.
13. Woese C.R., 1981, Archeabacteria, Sci. Am., 244:98-122.
14. Woese C.R., Kandler O. and Wheelis M.L., 1990, Towards a Natural System of Organisms: Proposal for the Domains Archea, Bacteria and Eucarya. Proc. Natl, Acad, Sci., 87: 4576- 4570.
15. Woese C. R., 1987, Bacterial evolution, Microbiological Reviews, 51: 221-271.

MBC 702: Techniques in Microbiology

Max. Marks -100

Unit –I

Basic principles and methods of sterilization & disinfection: Control of microorganisms by physical methods: heat, filtration and radiation; Chemical methods: Phenolics, alcohols, halogens, heavy metals, quaternary ammonium compounds, aldehydes and sterilizing gases; evaluation of antimicrobial agent effectiveness; Principle and function of Laminar air flow hood (LAF).

Unit-II

Basic principles for preparing microbes for light, dark field, phase contrast, confocal, fluorescent and electron (transmission and scanning) microscopy; Micrometry; Specimen collection, preparation and basic principles of simple, Gram, negative, capsule, endospore, flagella, acid- fast and fluorochrome staining.

Unit-III

Culture characteristics: Types of culture media, preparation of medium, Minimal requirements, Nutritional types; Methods of isolation and maintenance of pure cultures (Pour plate method, streak plate method & spread plate method); Cultivation of bacteria: aerobic & anaerobic; Growth curve of bacteria; Cultivation and morphology of molds; Yeast morphology; Cultivation and isolation of viruses; Preservation of culture: Short term & long term; Disposal of cultures.

Unit-IV

Principle and theory of biochemical activities of the microorganisms: Triple sugar –Iron agar test, ImVic test, Urease test, Catalase test, Oxidase test, Coagulase test, Sugar fermentation test, Hydrogen sulphide test and Nitrogen reductase test.

Practicals:

1. Laboratory rules and requirement, Bio safety equipments.
2. Microscopy (a) Dissecting
   (b) Compound
3. Microscopy: Phase contrast.
4. Media: (a) Liquid & solid media preparation.
   (b) Sterilization of glass wares and media.
5. Streak plate technique.
6. Pour plate technique and Spread plate technique.
7. Use of selective and differential medium; Use of indicator media.
8. Cultivation of microorganisms- nutritional & physical requirements; anaerobic cultivation.
9. Cultural characteristics of microorganisms.
10. Isolation and maintenance of pure cultures & Preservation of cultures.
11. Biochemical tests- Iron agar test, ImVic test, Urease test, Catalase test, Oxidase test, Hydrogen sulphide test, Nitrogen reductase test etc.

Suggested Books:

1. Atlas R.M., 1997, Principles of Microbiology. 2nd Edition, Mc Graw Hill Publications.
2. Balows A.A.G., Thuper M., Dworker W., Harder K. and Schleifer, 1991, The Prokaryotes, Springer.
3. Berg J.M., Tymoczko J.L. and Stryer L., 2007, Biochemistry Edition W.H. Freeman and Company, New York.
4. Davis R.Y. Adeberg E.A. and Ingram J.L., 1991, General Microbiology.
5. Nelson D. and Cox M.M., 2009, Principles of Biochemistry Edition W.H. Freeman and Company, New York.
6. Potter G.W.H and Potter G.W., 1995, Analysis of Biological Molecule: An Introduction to Principles, Instrumentation and techniques, Kluwer Academic Publishers.
7. Prescott, L.M., Harley J.P. and Klein D. A., 2007, Microbiology, 7th Edition, Mc Grow Hill.
8. Stainer, General Microbiology, 5th Edition, Printice Hall of India, Pvt. Ltd. New Delhi.

9. Talaro K.P. and Talaro A., 2006, Foundations in Microbiology, Mc Graw Hill Publications.
10. Verlog, Gunsales and Stainer, The Bacteria, Volumes I-V, Academic Press.
11. Wilson K. & Walker J., 2008, Principles and Techniques of Biochemistry and Molecular Biology. 6th Edition, Cambridge University Press.

MBC 703: Microbial Biochemistry

Max. Marks -100

Unit-I

Chemical properties of water: ionization and acid base chemistry; Carbohydrates- classification; configuration and conformation of monosaccharides, disaccharides polysaccharides,(structural–cellulose,peptidogycan,storage-glycogen) and glycoproteins; Lipids : General characters and classification, biosynthesis of saturated and unsaturated fatty acids; Structure and functions of triglycerides, phospholipids, glycolipids and steroids.

Unit –II

Structure of amino acids; Classification of essential amino acids based on polarity; Proteins: structure –secondary tertiary, quaternary& protein folding and stability; Levanthal paradox, Chaperones associated with folding; Properties of proteins: acid - base & solubility; Ramchandran plot; Methods of purification: General approach; Protein solubility chromatography, electrophoresis & ultracentrifugation; Sequencing of proteins: Preliminary steps, polypeptide cleavage, Edman degradation & reconstruction of protein sequence.

Unit –III

Laws of thermodynamics: First and second law, concept of free energy, oxidation reduction reactions; Enzymes: Classification and nomenclature, mechanism of enzyme action, enzyme inhibition, allostery, cofactors, coenzymes and prosthetic groups; Enzyme kinetics: Derivation of Michaelis - Menton equation and its significance, Lineweaver-Burke plot & Haldane-Briggs relationship.

Unit-IV

Chemical analysis of microbial cells for- carbohydrates, amino acids, proteins, lipids and nucleic acids; Structure and classification of secondary metabolites: Antibiotics (penicillin, streptomycin etc), alkaloids (Ergot toxins), flavanoids, vitamins and bacterial toxins.

Practicals:

1. Calibration of standard curve – Glycogen.
2. Calibration of standard curve - Protein.
3. Calibration of standard curve – Cholesterol.
4. Quantitative estimation of microbial total proteins (Lowry *et al.*, method).
5. Quantitative estimation of microbial / blood glucose & glycogen.
6. Quantitative estimation of microbial/eukaryotic lipids & total cholesterol.
7. Quantitative estimation of microbial DNA.
8. Quantitative estimation of microbial RNA.
9. Quantitative estimation of any one microbial enzyme.
10. Quantitative estimation of polyphenol & carotenoids.
11. Quantitative estimation of secondary metabolites - flavanoids.

Suggested Books:

1. Alexander R.R. and Griffith J.M., 1993, Basic Biochemistry Methods, 2nd Edition, Wiley.
2. Atlas R.M., 1997, Principles of Microbiology, 11th Edition, McGraw Hills.
3. Berg J.M., Tymoczko J.L. and Stryer L., 2007, Biochemistry, W.H. Freeman and Company.
4. Cohen, 2011, Microbial Biochemistry, 2nd Edition, Springer.
5. Conn E.E. and Stumpf P.K., 2006, Outlines of Biochemistry, 5th Edition, John Wiley & Sons.
6. Moat A.G. and Foster J.W., 2002, Microbial Physiology, 3rd Edition, John Wiley and Sons.
7. Nelson D.L.and Cox M.M., 2009, Lehninger Principles of Biochemistry, 5th Edition, W.H. Freeman and Company.
8. Plummer D., 1988, An Introduction to Practical Biochemistry, 3rd Edition, Tata McGraw Hills.
9. Potter G.H.W. and Potter G.W., 1995, Analysis of Biochemical Molecules: An Introduction to Principles, Instrumentation and Techniques, Kluwer Academics Publisher.
10. Stryer, 2001, Biochemistry, Fifth Edition, WH Freeman.

Dy. Registrar
(Academic)
University of Rajasthan
JAIPUR

11. Talaro K.P. and Talaro A., 2006, Foundation in Biochemistry, 6th Edition, Tata McGraw Hills.
12. Voet D. and Voet J.G., 1995, Biochemistry, 4th Edition, John Willey and Sons Inc.
13. Willey J., Sherwood L. and Woolverton C., 2007, Prescott Harley/Klein's Micriobiology, McGraw Hills.
14. Wilson E.K. and Walker J., Principles and techniques of practical biochemistry, 5th Edition, Cambridge.
15. White D., 2000, The Physiology and Biochemistry of Prokaryotes, 2nd Edition, Oxford University Press.
12. Zubzy G.L., 2008, Biochemistry, 4th Edition, Addison-Welsey Educational Publishers Inc.

MBE 701: Molecular Biology

Max. Marks -100

Unit –I

Nucleic acids: DNA structure; Chargaff's rule; Types of DNA; Reannealing and hybridization; DNA replication in prokaryotes and eukaryotes: Polymerases, replication origin, initiation, elongation and termination; Synthesis of telomeric DNA; topological properties: linking number, super helicity, mechanism of topoisomerases; Drugs & inhibitors of DNA synthesis.

Unit –II

Transcription: Prokaryotes - polymerase, promoter, initiation, elongation and termination; Eukaryotes- promoters, initiation, elongation, termination and post translational modification of mRNA [capping & polyadenylation, Splicing: L & Y splicing (Group I and II introns) hRNA using spliceosome/snurposome]; Ribozymes; Inhibitors of transcription.

Unit –III

Types of RNA: Structural features (mRNA, rRNA, tRNA); Genetic code: Degeneracy of the code, three rules governing the code; Protein synthesis in prokaryotes and eukaryotes: initiation, elongation and termination; Protein synthesis on membrane bound ribosomes: signal hypothesis, post translation modification in ER and Golgi complex; Drugs & inhibitors of protein synthesis.

Dy. Registrar
(Academic)
University of Rajasthan
JAIPUR

Unit –IV

Regulation of gene expression: Operon concept, negative & positive regulation, inducers, co-repressors and catabolite repression; Negative regulation-*Lac* operon; Positive regulation- *Ara* operon; Regulation by attenuation –*trp* operon; Anti termination –N protein and *nut* sites in lambda.

Practicals:

1. Preparation of buffers and solutions (Normality & Molarity).
2. DNA isolation from different cell types: Microbes and eukaryotic cell (Yeast).
3. Check for purity of isolated DNA sample: Microbes and eukaryotic cell (Yeast).
4. Quantification of DNA (microbes & eukaryotic cell) using spectrophotometer.
5. Microbial DNA denaturation and determination of Tm and G+C content.
6. Agarose gel electrophoresis of bacterial DNA.
7. Total RNA isolation from bacterial cells.

Suggested Books:

1. Bale J.W., 1994, Molecular Genetics of Bacteria, John Wiley & Sons.
2. Biology of the Gene, 6th Edition, CSHL Press.
3. Clarke D.P., 2005, Molecular Biology. 1st Edition, Elsevier Academic Press.
4. Friedberg C., Walker G.C. and Wolfman S., 1995, DNA repair and mutagenesis. ASM Publications.
5. Friefelder D., 1995, Molecular Biology. 2nd Edition. Narosa Publishing House.
6. Gardner E.J., Simmons M.J. and Snustad D.P., 1991, Principles of Genetics. 8th Edition. John Wiley & Sons Inc.
7. Larry S. and Wendy, 1997, Molecular Genetics of Bacteria. ASM Publications.
8. Lewin, 2000, Gene VII. Oxford University Press.
9. Maloy, 1994, Microbial Genetics. Jones & Bartlett Publishers.
10. Pierce B.A., Genetics- A Conceptual Approach, 2nd Edition, W. H. Freeman & Co.
11. Sambrook J. and Russell D. 2001 Molecular Cloning: A laboratory manual. 3rd Edition, CSHL Press.
12. Streip and Yashbin, 1991, Modern Microbial Genetics. Niley Ltd.

MBE 702: Biostatistics

Max. Marks -100

Unit-I

1. Introduction to Biostatistics
   - 1.1 Definitions of biostatistics
   - 1.2 Scope and applications of biostatistics
   - 1.3 Collection, organization and representation of data (graphical & diagrammatic)

2. Measures of Central tendency & Dispersion (Direct, Short cut and Step deviation methods where ever applicable)
   - 2.1 Mean, median & mode
   - 2.2 Mean deviation
   - 2.3 Standard deviation & standard error
   - 2.4 Variance & coefficient of variation
   - 2.5 Confidence interval and level of confidence

Unit II

3. Correlation and Regression
   - 3.1 Types of correlation
   - 3.2 Methods of studying correlation
   - 3.3 Regression analysis

4. Probability
   - 4.1 Basic concepts related to probability theory
   - 4.2 Classical, Posteriori, Personalitic &Axiomatic probability
   - 4.3 Theorems of probability & Probability distributions
   - 4.4 Properties of Binomial, Poisson, Normal and skewed distribution & their application in biology

Unit III

5. Tests of Significance
   - 5.1 Hypothesis testing & level of significance
   - 5.2 Type I & II errors
   - 5.3 Significance of difference between means
   - 5.4 Z-test

Dy. Registrar
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5.5 Students t-test (Unpaired & Paired)

6. Analysis of Variance
   6.1 One way classification
   6.2 Two way classification
   6.3 F-test (Variance ratio)

Unit IV

7. Chi Square test
   7.1 Testing Goodness of fit
   7.2 Chi Square distribution and characteristics
   7.3 Applications of Chi-square test
   7.4 Yate's correction

8. Computational statistics using MS Excel.

Practicals:

1. Preparation of frequency tables, Graphical representation of data: bar diagram, histogram, frequency polygon, frequency curve and ogives or cumulative frequency curve and pie diagram.
2. Measures of central tendency, Mean deviation, standard deviation and standard error (Individual, discrete and continuous series – Direct, short cut and step deviation).
3. Plotting of scatter diagram and regression lines. Calculation of correlation coefficient, regression equation and regression analysis.
4. Test of significance by student's t- test, F-test & chi-square test.
5. Statistical calculations using MS Excel.
6. Preparation of graphs using MS Excel.

Suggested Books:

1. Bailey N.T.J., 2000, Statistical Methods in Biology, English Univ Press.
2. Bansi L., 1968, Mathematics of Probability of Statistics, S. Chand & Co., Delhi.
3. Baxevanis A.D. and Ouellette, 2005, Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd Edition, John Wiley and Son Inc.
4. Campbell R.C., 1974, Statistics for Biologist, Cambridge University Press.
5. Gralla P., 2000, How the Internet Work, Tech Media.

6. Kenny J.F. and Keeping E.S., 1964, Mathematics of Statistics Part I & II, Affiliated East-West Press Ltd, New Delhi.
7. Mount D.W., 2004, Bioinformatics Sequence and Genome Analysis, CSHL Press.
8. Shina P.K., 2002, Fundamentals of Computers, BPa Publications, New Delhi.
9. Snedecor G.W. and Cochram W.G., 1968, Statistical Methods, Oxford & IBH, Delhi.
10. Tramontano A., 2007, Introduction to Bioinformatics, Chapman & Hall/CRC.
11. White R., 2000, How Computer Works, Tech Media.
12. Zvelebil M. and Baum, 2008, Understanding Bioinformatics, Chapman & Hall/CRC.

MBE 703: Bioinstrumentation

Max. Marks -100

Unit I

Microscopy: Principles of microscopy, magnification power, resolution limit, resolving power, numerical aperture; Principles and application of light microscopy, properties of light, bright field, dark field, phase contrast and fluorescent microscopy; Principles and application of electron microscopy- transmission and scanning electron microscopy; Newer techniques in microscopy- confocal microscopy, scanning probe microscopy (scanning tunnelling microscope and atomic force microscope).

Unit II

pH meter, Centrifugation: Basic principles of analytical and preparative centrifuge, differential and density gradient, zonal and isopycnic centrifuge, High speed centrifuge and ultra centrifuge; Sedimentation coefficient, factors affecting sedimentation coefficient and application.

Unit III

Chromatography: Principles, types and applications of partition, adsorption, gel filtration, paper and thin layer chromatography; Affinity, ion exchange and gas chromatography; High performance liquid chromatography and Fast Performance Liquid Chromatography (FPLC).

Electrophoresis: Principle, types and applications, frontal and zonal electrophoresis, paper, starch gel, Polyacrylamide and agarose gel electrophoresis; Isoelectric focussing and

Isotachophoresis; Two dimensional gel electrophoresis and pulse field gel electrophoresis; Immunological techniques: immunoelectrophoresis, immunodiffusion & immuno fluoroscence.

Unit IV

Spectroscopy: Basic principles, principles and application of visible, ultraviolet, infrared and mass spectroscopy; Principles and application of NMR and ESR; Principles and application of colorimetry, fluorescence flame photometry, Atomic Absorption spectroscopy & Raman spectroscopy.

Radioisotopes –Types ;Radioactive units ; Radioactive Decay – Types and Measurement, Principles and Applications of Geiger Muller counter , Liquid Scintillation counter, Proportional counter ,Gamma counter, Film badge, Pocket dosimeter, Thermoluminescence dosimeter ,Trefoil , Autoradiography, Radio immunoassay (RIA) & Radiation dosimetry.

Practicals:

1. Studies on pH titration curves of amino acids / acetic acid.
2. Determination of pKa values and Henderson-Hasselbach equation (at least two).
3. Preparation of samples using differential centrifuge.
4. Study of microbes –Fluorescent microscope.
5. Separation of bacterial lipids/amino acids/sugars/organic acids by TLC.
6. Separation of bacterial lipids/amino acids/sugars/organic acids by Paper chromatography.
7. Separation of biomolecules by Ion exchange / Gel permeation / Affinity chromatography.
8. Isolation of genomic DNA from bacteria/yeast and separation of DNA by gel electrophoresis.
9. Separation of microbial proteins by gel electrophoresis.
10. Study of UV absorption spectra of macromolecules (protein, nucleic acid & bacterial pigments).

Suggested Books:

1. Freifelder D. Physical Biochemistry: Application to Biochemistry and Molecular Biology. Freeman Publications.

2. Walker J. & Wilson K., 2000, Principle & Technique – Practical Biochemistry 5th ed.

3. Wilson & Keith. Principles and Techniques of Practical Biochemistry. Cambridge Publications.

4. Rana SVS. Biotechniques. Rastogi Publications, Meerut.

Syllabus M.Sc. Microbiology

Semester II

MBC 801: Bacteriology

Max. Marks -100

Unit I

Microbial evolution and diversity ,Taxonomic ranks, Phenetic classification, Numerical taxonomy,16s rRNA, Major characteristics used in taxonomy, Microbial phylogeny-Molecular characteristics, Phylogenetic trees, rRNA, DNA & proteins as indicators of phylogeny, Polyphasic taxonomy.

Unit II

Morphology and ultrastructure of bacteria: Size , shape and arrangement of bacteria, structure and chemical composition of cell wall of Gram positive and Gram negative bacteria and Archaea; Structure , composition and function of cell membrane, capsule, flagella, pili, gas vesicles, cytoplasmic matrix reserve food materials, nucleoid, plasmids.

Unit III

Bacterial life cycles, nutrition, respiration & reproduction; Economic importance of bacteria. Endospore : structure, formation and stages of sporulation; Chemoautotrophs, chemoheterotrops, Nutritional categories among microorganisms, Nutritional requirements in bacteria and nutritional categories, the requirement of carbon, nitrogen and sulphur, growth factors, the role of oxygen, continuous culture, their applications, chemostats and turbidostats.

Unit IV

Antibacterial agents: General consideration and classification; Bacterial resistance to antibacterial agents-Acquisition of bacterial resistance, Mechanism of bacterial resistance, Bacterial resistance to drug classes & antibiotic susceptibility testing.

Practicals:

1. Quantitation of viable cells in bacterial culture.
2. Micrometry of bacterial cells.
3. Study of microorganism morphology: Hanging drop method and wet mount.
4. Bacterial motility.
5. Preparation of bacterial smears and Negative staining.
6. Differential staining : Gram staining.
7. Differential Staining: Acid – Fast staining.
8. Differential Staining: Endospore staining.
9. Differential Staining: Capsule staining.
10. Differential Staining: Flagella staining.
11. Cytoplasmic inclusion staining: (a) Poly –β- hydroxybutyrate (PHB) granules.
    (b) Metachromatic granules.

Suggested Books:

1. Baron S. Medical Microbiology. 4th edition, Galveston (TX).
2. Brown A., 1996, Benson's Microbiological Applications Complete Version. (Kindle edition).
3. Lehmann KB. Atlas and Principles of Bacteriology and Text-Book of Special Bacteriologic Diagnosis. (Karl Berhard) Andesite Press.
4. Morrey CB. The Fundamentals of Bacteriology.
5. Snyder L, Joseph E. Peters, Tina M. Henkin ,Wendy Champness , 2007.Molecular Genetics of Bacteria. 4th edition . ASM Press.

MBC 802: Microbial Metabolism & Physiology

Max. Marks -100

Unit –I

Microbial nutrition & growth: Nutritional categories of microorganisms; Nutritional requirements; Measurement of microbial growth, direct & indirect measurement of microbial growth; Influence of environmental factors on microbial growth.

Dy. Registrar
(Academic)
University of Rajasthan
JAIPUR

Unit-II

Respiratory metabolism: Glycolytic pathway of carbohydrates breakdown, glycolysis, (Embden Meyerhoff pathway), Kreb's cycle and Entner – Duoderoff pathway, Phosphoketolase pathway, Pentose phosphate pathway, Oxidative and substrate level phosphorylation, Gluconeogenesis, Glycogen metabolism, glyoxylate cycle, fermentation of carbohydrates and homo- & hetero-lactic fermentation.

Unit-III

Bacterial photosynthesis: Classification of photosynthetic bacteria,(Anoxygenic,oxygenic); photoheterotrophs; Members of prochlorophyta; Unclassified bacteria; Photosynthetic pigments: Bacteriochlorophylls ; Metabolism in photosynthetic bacteria; photosynthetic electron transport system; mechanism of photosynthesis (cyclic & noncyclic); Calvin Benson cycle.

Unit –IV

Nitrogen fixation in symbiotic and free living system; oxygen and hydrogen regulation of nitrogen fixation; nitrification, denitrification and ammonifying bacteria; Pathway of nitrate assimilation in photosynthetic and non photosynthetic systems; transamination and deamination reaction; Synthesis of essential & non essential amino acids and Synthesis of peptidoglycans & polyamines.

Practicals:

1. Physiological differentiation of microorganisms of TSI differential media.
2. Study of nitrification.
3. Isolation and identification of symbiotic nitrogen fixer (Rhizobium) from root nodules.
4. Isolation and Identification of free living nitrogen fixer from soil.
5. Study of ammonification.
6. Carbohydrate fermentation tests **(minimum three).**
7. Study of chemolithotrophs.
8. Litmus milk-homo-fermentation/ hetero-fermentation.
9. Determination of microbial growth.
10. Effect of factors – temperature & pH on bacterial growth.

Suggested Books:

1. Atlas R.M., 1997, Principles of Microbiology. 2nd Edition, Mc Graw Hill Publications.
2. Berg J.M., Tymoczko J.L. and Stryer I., 2007, Biochemistry. 6th Edition, W.H. Freeman and Company, New York.

3. Nelson D. L. and Cox M. M., 2009, Lehninger's Principles of Biochemistry, W. H. Freeman.
4. Potter G.W.H and Potter G.W., 1995, Analysis of Biological Molecules: An introduction to principles, instrumentation and technique, Kluwer Academic Publications.
5. Prescott L.M., Harley J.P. and Klein D.A., 2007, Microbiology, 7th Edition, Mc Graw Hill.
6. Stryer, 2001, Biochemistry. 5th Edition, W.H. Freeman.
7. Talaro, K.P. and Talaro A., 2006, Foundations in Microbiology, Mc Graw Hil. Publications.
8. Willey J., Sherwood L. and Woolverton C., 2007, Prescott V Harley/Klein's Microbiology, Mc Graw Hill.

MBC 803: Medical Microbiology

Max. Marks -100

Unit I

Normal microbial flora in human (skin, mouth, upper respiratory tract &eye) and its role, Normal human flora as pathogen, Anatomic position of normal flora; Pathogenic properties of bacteria –Colonization, invasion, production of toxins (exotoxins & endotoxins); Antimicrobial defences of host;Cellular mechanisms of antimicrobial defences; Pathogenesis of viral infections; New vaccine technology, recombinant DNA and protein based vaccines, synthetic peptide vaccines, plant based vaccine, multivalent subunit vaccines and vaccine clinical trials.

Unit II

General characteristics, Morphology, Growth, Pathogenicity, Laboratory diagnosis and Therapy of pathogenic bacteria: *Pneumococci, Neisseriae, Enteric bacilli, Pseudomonas* and other non fermenting bacilli, *Haemophilus, Bordetella, Clostridia, Mycobacteria, Actinomycetes, Rickettsias, Mycoplasmas, Shigella, Vibrio &Yersinia.*

Unit III

Structure, Reproduction, Pathogenicity, Diagnosis, Therapy and Epidemiology of disease caused by Fungus: *Crytococcus neoformans, Blastomyces dermatitidis, Trichophyton ,Histoplasma*

Dy. Registrar
(Academic)
University of Rajasthan
JAIPUR

capsulatum, Coccidioides immites, Candid albicans, Aspergillus fumigates, Phacomycetes, Sporothrix schenckii, Eumycotic Mycetoma & Microsporum spp.

Unit IV

Properties, Pathogenesis, Laboratory diagnosis, Epidemiology, Control &Treatment of virus: Herpes virus (*H.simplex, H.zoster, Epstein-Barr viruses*), Pox viruses, Picornaviruses, Adenoviruses & Rubella virus.

Multiplication, Pathogenesis and Oncogenic activity: (a) Oncogenic DNA viruses (Papovaviruses - Papilloma viruses, Hepatitis B virus, Oncogenic Herpes viruses); (b) Oncogenic RNA viruses (Lentivirus, HIV, Primate and Human type C Oncovirus).

Practicals:

1. (a) Laboratory rules and regulation in Pathological laboratory.

   (b) Collection of specimen – Basic concepts, Transport containers for anaerobic specimens & collection.

2. Techniques for transfer of clinical specimens & selection of primary culture media, Interpretation of culture.

3. Identification based on metabolic characteristics.

4. Antibiotic susceptibility testing.

5. New laboratory technologies for detection of infectious diseases.

Suggested Books:

1. Baron S., 1996, Medical Microbiology, 4th ed. Galveston (TX) .
2. Geo. F. Brooks & Stephen A. Morse. Jawetz, Melnick, & Adelberg's Medical Microbiology. 26th edition. McGraw-Hill.
3. Kenneth J. Ryan, C. George Ray. Sherris Medical Microbiology, 5edition
4. Kenneth J. Ryan, MD; Sean Elliott, MD; Lynn Joens, PhD; Chuck Sterling, BS, PhD (Tucson, AZ) ,Paul Pottinger, MD (Seattle, WA)., 2014, Sherris Medical Microbiology, 6th ed. McGraw-Hill Education.
5. Murray PR, Rosenthal KS, Kobayashi GS & Pfaller MA., 2015, Medical Microbiology 8th ed. MosbyInc. St Louis, Missouri.

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MBE 801: Food Microbiology

Max. Marks -100

Unit:1

Important microbes involved in spoilage of food: Meat, poultry, vegetables & dairy products; Microbial deterioration of cereals, pulses, fish & sea foods during storage; Feed for cattle: Use of microbes and microbial enzymes in the improvement of nutritive quality of feed.

Unit: II

Toxins: Bacterial and mycotoxins, important microbes secreting toxins, chemical nature of important toxins, their role in food poisoning; Physiology and mechanism of action, modification and detoxification, prevention and control of toxin contamination. Starter cultures- their biochemical activities, Production and preservation of fermented foods- Soya sauce, sauerkraut, meat – sausages & baker's yeast.

Unit III

Microbial biomass and single cell proteins; Uses of microbes in meats and poultry products vegetables etc.; Low calorie sweeteners, flavour modifiers & food additives; Food quality monitoring Indian fermented food.

Unit IV

Microbial enzymes in food industry, Tea and coffee fermentations, Vinegar, Wine & Beer production; Food preservation methods, Use of low & high temperature, radiations – UV, Gamma and Microwave, chemicals and naturally occurring anti microbials.

Practicals:

1. Statutory tests for microbiological analysis of canned foods.
2. Determination of bacteria in spoiled canned foods.
3. Single cell Protein (SCP) cultivation.
4. Preparation of fermented food & beverages: Sauer Kraut, Koji & Soya sauce.
5. Bacterial count in any of the two food products (fermented & non fermented).
6. Sampling & analysis of microbial load on food contact surfaces.
7. Isolation and identification of common microorganisms spoiling food: Bacteria & fungi.
8. Aflatoxin production from fungi.

Suggested Books:

1. Banwart GJ, Basic Food Microbiology. CBS Publishers &Distributers.

2. Frazier WC and Westhoff D C, Food Microbiology. Tata McGraw-Hill Publishing Company Limited, New Delhi.

3. Adams MR and Moss MO, Food Microbiology. New Age International Ltd.

MBE 802: Environmental Microbiology

Max. Marks -100

Unit-I

Microbes in extreme environments; Environment induced genetic and physiological adaptation in microbes; Disinfection of potable water supplies and hospital wastes; Bacterial indicators of water safety ; Microbial assessment of water quality; Standard for tolerable levels of fecal contamination.

Unit-II

(a) Biodegradation and Bioremediation: Microbial degradation of lingo-cellulosic substances, keratin and chitin; Bioremediation: Microbial degradation of herbicides, pesticides, hydrocarbons including polycyclic (petroleum, gas production, fossil fuel & polychlorinated biphenyls etc.), oil spills, heavy metals, chlorinated and polychlorinated compounds; Biological treatment of effluents of sugar, pulp and paper industry.

(b) Biodeterioration: Biodeterioration of buildings and monuments of cultural heritage, microbial deterioration of paper, textile, leather, rubber, glass, paints and metals; Principal methods for their protection.

Unit –III

Aerobic treatment of waste water (Trickling filters, Rotating biological contractors, Fluidized bed reactors, Activated sludge, Oxidation ponds), anerobic treatment of waste water (Anaerobic contact digesters, Packed bed reactors, Up-flow anaerobic sludge blanket reactors) Advanced waste water treatment for removal of suspended solids, nutrients (N&P),Oil and grease, Toxic compounds and dissolved inorganic substances, Solid waste disposal (sanitory landfills andf compositing).

Dy. Registrar
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University of Rajasthan
JAIPUR

Unit –IV

Microbial diversity; Microbiology of air, soil & water; Techniques in environmental microbiology: Methods for determination of numbers, biomass and activities of microbes in soil, water, plant surfaces and dead organic materials; Bioremediation techniques: *in situ* (Bioventing, air sparging , liquid delivery system, aerobic bioremediation & phytoremediation) and *ex situ* (land farming, compositing, biopiling & slurry –phase).

Practicals:

1. Enumeration of micro-organisms from air.
2. Enumeration of micro-organisms from soil.
3. Micro-organisms degrading oil/textile dyes/petrol.
4. Biodeterioration of paper/textile.
5. Bacteriological examination of water (Potable /hospital wastes):
   a. Presumptive test
   b. Confirmed test
   c. Completed test
6. Identification of pathogenic microbes in water samples.
7. Chemical Oxygen Demand (COD)
8. Biological Oxygen Demand (BOD).
9. Total dissolved solids (TDS).
10. Total hardness.
11. Fluoride and Nitrate content.

Suggested Books:

1. Atlas R.M. and Bartha R., 1993, Microbial Ecology, Benjamin Cummings Publishing Co, Redwood City, CA.
2. Baker K.H. and Herson D.S., 1994, Bioremediation, McGraw Hills Inc., NY.
3. Christon J.H., 2001, A Manual of Environmental Microbiology, ASM Publications.
4. Colwd D., 1999, Microbial Diversity, Academic Press.
5. Forster C.F. and John D.A., 2000, Environmental Microbiology, Ellis Horwood Ltd. Publications.
6. Grant W.D. and Long P.E., 1981, Environmental Microbiology, Kluwer Academic Publishers.
7. Hurst C.J., Crawford R.L., Garland J.L., Lipson D.A. and Mills A.L., 2007, Manual of Environmental Microbiology, ASM Press.

Dy. Registrar
(Academic)
University of Rajasthan
JAIPUR

8. Jjemba P.K., 2004, Environmental Microbiology: Principles and Applications, Science Publishing Inc.
9. Johri B.N., 2000, Extremophiles, Springer Verlag, NY.
10. Maier R., Pepper I., and Gerba C., 2008, Environmental Microbiology, Academic Press.
11. Mitchel R., 2009, Environmental Microbiology, 2nd Edition, Wiley-Blackwell.
12. Pepper I., Gerba C.P. and Brusseau M.L., 2006, Environmental and Pollution Science, Academic Press, USA.
13. Ralph M.A., 1997, Environmental Microbiology, John Wiley and Sons Inc.
14. Singh A., Kuhad R.C. and Ward O.P., 2009, Advances in Applied Bioremediation, Springer.
15. Varman A.H. and Evans M.G., 2000, Environmental Microbiology, Manson Publishing Ltd.

MBE 803: Dairy Microbiology

Max.Marks : 100

Unit I

Milk – Contents & their % ; Microbiology of milk and milk processing; Microbiology of raw milk, Processed milk, Cream & butter, concentrated milk, flavoured milk & dried milk; Microbiology of ice cream & related products.

Unit II

Starter cultures-Fermented milk, Therapeutic milk, Butter , Yoghurt, Soft cheese & hard cheese; Introduction to probiotics, prebiotics & synbiotics; Quality control in dairy industry; Hazard Analysis Critical Control Point (HACCP).

Unit III

Role of microbes in milk and dairy products; Microbiological examination of raw / pasteurized milk, standard plate count, direct microscopic count and reductase test, composition of milk, sources of contamination of milk, ability of milk to cause diseases.

Unit IV

Pathogens: Arthrobacter spp., *Bacillus cereus, Campylobacter spp., Clostridium botulinum, Clostridium perfringens, Cronobacter (Enterobacter) sakazakii , Escherichia coli, Listeria mocytogenes,Mycobacterium., Micrococcus., Salmonella spp ,Staphylococcus aureus & Yersinia enterocolitica, Aspergillus spp., Fusarium spp., Mucor, Penicillin, Geotrichum, Cladosporium , Yeast., Phoma spp., Cluvaromysis, Beberomysis, Alternaria,Eurotium.*

Cleaning and sanitizing in milk production & processing; Control of microorganism in dairy processing; Regulatory control of milk &dairy products; Treatment of dairy wastes.

Practicals:

1. Microorganisms in cheese spoilage.
2. Detection of fungal spoilage of dairy products.
3. Bacterial contamination in milk.
4. Determination of bacteria number: Standard plate count.
5. Determination of bacteria number: Direct microscopic count.
6. Methylene Blue Reductase Test (MBRT).
7. Turbidity testing for milk.
8. Determination of casein hydrolysis in milk.
9. Presumptive test for coliforms in milk & butter.
10. Fermented milk.
11. Identification of microbes in curd / chach using differential staining.

Suggested Books:

1. Britz T. and Robinson R. K., 2008, Advanced Dairy Science and Technology. Wiley Blackwell.
2. Elmer H. M and James S., 2001, Applied Dairy Microbiology. 2nd edition. CRC Press.
3. Robinson R K., 2002 Dairy Microbiology Handbook: The Microbiology of Milk and Milk Products. 3rd edition. Wiley.
4. Yousef A E. and Carlstrom C., 2003, Food Microbiology: A Laboratory Manual. Wiley.

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Syllabus M.Sc Microbiology

Semester III

MBC 901: Virology

Max.Marks: 100

Unit –I

General virology: Brief outline on discovery of viruses, nomenclature & classification of viruses; Distinctive properties of viruses, morphology & ultra structure; Capsids & their arrangements; Type of envelopes and their composition; Viral genomes: their types and structures, replication of viruses; Viron, viroids & prions.

Unit-II

Bacteriophages: Classification; morphological groups; virulent dsDNA phages (T-4 phage), one step growth curve, ssDNA phage (ΦX174); bacteriophage typing; Lytic cycle, Lysogenic cycle; Cyanophages: Morphology and growth cycle; Mycophages : types; Taxonomic affinity.

Unit-III

General characters of major plant viruses: Tobacomosaic virus group (TMV); Tymovirus group (circular mosaic virus); Tomato spotted wilt virus; Cauliflower mosaic virus; Effects of these viruses on plants; General characters of major human and animal viruses: Adenovirus, Poxvirus, Picornavirus, Retrovirus & Reoviruses.

Unit-IV

Cultivation of viruses: Growth of viruses in embryonated egg, experimental animals and cell cultures, primary and secondary cell lines, suspension cell cultures and monolayer cell cultures; Assay of viruses: Physical and chemicals methods of assay (protein, nucleic acid, radioactivity tracers, electron microscopy etc); Infectivity assay of plant viruses & animal viruses, plaque method, pock counting and end point method.

Practicals:

1. Viral plaques assay.
2. Study of plant virus-TMV.
3. Study of plant virus-CaMV.
4. Study of animal viruses.

Dy. Registrar
(Academic)
University of Rajasthan
JAIPUR

5. Study of retroviruses.
6. Growth of viruses in embryonated eggs.
7. One step growth curve of (ΦX174) virus.
8. Use of suspension /monolayer cell cultures for viral cultivation.

Note: Photographs to be supplemented wherever required.

Suggested Books

1. Cann A.J., 1997, Principles of Molecular Virology. 2nd edition, Academic Press, California.
2. Cann A.J., 2001, Principles of Molecular Virology. 3rd edition, Elsevier Academic Press.
3. Carter J. and Saunders V., 2007, Virology; Principles and Applications, 1st edition, John Wiley & Sons.
4. Conrat H.F., Kimball P.C. and Levy J.A., 1988, Virology. 2nd edition, Prentice Hall, Englewood Cliff, New Jersey.
5. Dimmock N., Easuton A. and Leppard K., 2005, Introduction to Modern Virology. 5th edition, Blackwell Publishing.
6. Dimmock N.J. and Primrose S. B., 1994, Introduction to Modern Virology. 4th edition, Blackwell Scientific Publications, Oxford.
7. Flint S.J., Enquist L.W., Krung R. Racaniello V.R. and Skalka A.M., 2004, Principles of Virology. ASM Press.
8. Granoff A. and Webster R.G., 1999, Encyclopaedia of Virology. Volume I, II and III, San Diego Academic Press.
9. Hull R., 2002, Plant Virology. 4th Edition, Academic Press.
10. Knipe D.M. and Howley P.M., 2006, Fields Virology. Lippinocott-Raven, Philadelphia, USA.
11. Luria S.E., 1978, General Virology. 3rd edition, Jhon Wiley and Sns. New York.
12. Parker T., Lerline M., Collier H., 1990, Principles of Bacteriology, Virology and Immunity. 7th Edition.
13. Ram Reddy S. and Reddy S. M., 2007, Essentials of Virology Scientific Publishers (India) Jodhpur.

14. Straus J.H. and Straus E.S., 1998, Evolution of RNA Viruses. Am. Rev, Microbiology, 42; 627-83.
15. Wanger E.K., Hewiett M., Bloom D. and Camerini D., 2007, Basic Virology. 3rd edition, Blackwell Publishing.

MBC 902: Microbial Genetics

Max. Marks: 100

Unit-I

Gene: Seymour Benzer experiment, complementation test, cistron, recon & muton; Mutation mapping at molecular level; Mutation: Spontaneous mutation, induced mutation and mutagens, molecular mechanism of mutagens, suppressor, intragenic & intergenic mutation, Isolation and detection of bacterial mutants; DNA repair: direct repair, excision repair (base and nucleotide), mismatch repair, SOS repair and translesion DNA synthesis.

Unit –II

Homologous recombination: Holliday junction (single strand & ds break); homologous recombination protein: Rec A, Ruv AB complex & Ruv C, Rec BCD pathway and Rec F pathway, FLP/FRT and Cre / Lox system; Transposable elements: Classes and genetic organisation of transposable elements, insertion sequences (IS elements), composite and complex transposons & mechanism of transposition.

Unit-III

Gene transfer mechanisms: Bacterial transformation (mechanism of transformation, transfection & competence); Transduction: Generalized transduction, specialized transduction & abortive transduction; Conjugation: effective contact & pili in conjugation, the "F"factor, conjugal transfer process, high frequency recombination (Hfr) strains, the order of chromosome transfer, formation of F'(F prime), mapping by using transformation, transduction and conjugation,Horizontal gene transfer.

Unit IV

Genome organisation: Prokaryotic genome- nucleoid; Eukaryotic genome: Structure of chromatin, nucleosome, organisation & remodelling and high order organization of chromosomes, centromere & telomere; DNA methylation and gene imprinting; C value paradox and Cot curves; repetitive and non repetitive DNA sequences; Cot ½ and Rot ½ values; Pseudogenes, gene families & gene cluster super families.

Practicals:

1. Study of conjugation in *E. coli.*
2. Effect of UV radiations and repair mechanisms in bacteria.
3. Isolation of antibiotic resistant mutants by disc methods.
4. Isolation of antibiotic resistant mutants by gradient plate method.
5. Isolation of mutants by replica plate method.
6. Ames test.
7. Preparation of competent cells.
8. Transformation of *E.coli* with plasmid DNA.
9. Transduction.
10. Isolation of plasmid DNA.

Suggested Books:

1. Brown T.A., 2006, Gene Cloning and DNA Analysis. 5th edition, Blackwell Scientific Publishing, Oxford.
2. Glick B.R. and Pasternak J.J., 2003, Molecular Biotechnology. ASM Press Washington D.C.
3. Lewin B., 2007, Gene IX. Jones and Bartlett Publishers, Sudbury, Massachusetts.
4. Maloy S.R., Cronan J.R. and Freifelder D., 2009, Microbial Genetics. 2nd edition, Narosa Publishing House, New Delhi.
5. MHRB,ASM publications.
6. Snyder L. and Champness W., 2007, Molecular Genetics of Bacteria. 3rd edition, ASM Press.
7. Streips U.N. and Yasbin R.E., 2002, Modern Microbial Genetics. 2nd edition, Wiley Publishers.
8. Trun N. and Trempy J., 2004, Fundamental Bacterial Genetics. 1st edition, Blackwell Science Publishers.

MBC 903: Computational Biology

Max. Marks: 100

Unit I

Introduction to computers and bioinformatics: Types of computer operating systems; Servers and algorithms in Bioinformatics; objectives, Scope, application, advancements and limitations of bioinformatics; Database: Concept , Biological data and Biological Database-Primary, secondary and structural; Classification of databases based on the types of data and mode of data storage; Examples of biological database (Gen Bank, PIR, Swiss-Prot, PDB,DDBJ, NCBI, EMBL etc.); Biological data management and retrieval systems; Perspectives & Limitations of biological databases; System modelling & metabolomics -Concept & principle.

Unit-II:

Biological sequences: DNA, RNA and Protein sequences, Formats of biomolecular sequence files (Fasta, genbank, gcg, etc.); Sequence alignment: Concept of Local and Global sequence alignment; Single sequence alignment ; Multiple sequence alignment(MSA)-Progressive &Iterative method; Concept of sequence Identity, Similarity and Homology; Methods used in alignment algorithms: Dot plot and Dynamic programming methods; Dot matrix- Scoring matrices: PAM and BLOSUM; Database searching: Heuristic method of similarity search; Sequence similarity search tools: BLAST, variants of BLAST (BLASTn, BLASTp, PSI-BLAST,PHI-BLAST etc) and FASTA; Domain and Motif search in sequence.

Unit-III:

Phylogenetic trees: Basic concept and types of phylogenetic trees-Rooted, Unrooted, Bifurcating Multi-furcating etc ; Molecular evolution and Molecular phylogeny -; Gene phylogeny vs Species phylogeny; Methods for construction of phylogenetic trees: Distance based, Character based, Parsimony method; Bioinformatics tools for Phylogenetic analysis and phylogenetic tree construction: ClustalΩ/ClustalW, Mega, iTOL.

Unit-IV

(a) Structural Bioinformatics: Basics of protein structure determination (X-ray crystallography) and structure prediction - Secondary structure prediction – Chou-Fasman, GOR methods(SOPMA), Neural network concept, transmembrane structure prediction and Tertiary structure prediction/Homology modeling , Protein structure database (PDB);

Structural alignment, comparison, protein – protein interaction database-STRINGS,DIP ; classification of proteins. Bioinformatic basis of protein structural classification: CATH and SCOP.

(b) DNA sequence analysis: ORF prediction, Gene and promotor prediction in prokaryotes and eukaryotes; Categories of gene prediction programs; Genome mapping, assembly and comparison; Functional genomics: Microarray and SAGE; Next generation sequencing. Molecular visualisation software for architecture & topologies of proteins and DNA – RasMol, Cn3D, SPDBV etc.

Practicals:

1. Study of database.
2. Single Sequence and Multiple Sequence alignment by BLAST and FASTA.
3. Sequence retrieval from database.
4. Phylogenetic tree construction using ClustalW and Mega-4.
5. Analysis of molecular variance (AMOVA)
6. NTSYS-pc analysis of DNA bands.
7. Analysis of protein and nucleotide sequence
   (a) ORF and Gene finding
   (b) Motif finding
   (c) Conserved domain finding
8. Classification of protein using CATH and SCOP.
9. Visualization of proteins using various visualization tools.
10. Study of relationships among various biochemical molecules using STRING.

Suggested Books:

1. Baxevanis A. D. and Ouellette B. F .F., 2001, Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. 2nd edition, John Wiley & Sons, Inc., Publication.
2. Lesk A. M., 2005, Introduction to Bioinformatics, 2nd edition Oxford University Press.
3. Mount D., 2004, Bioinformatics: Sequence and Genome Analysis. 2nd edition, Cold Spring Harbor Laboratory Press, New York.
4. Gottfried, B.S., 1996, Schaum's Outline of Theory and Problems of Programming with C, McGraw-Hill ISBN 10 0070240353.
5. Xiong Jin., 2006, Essential Bioinformatics, I st edition, Cambridge University Press.

Dy. Registrar
(Academic)
University of Rajasthan
JAIPUR

6. Pevsner J., 2009, Bioinformatics and Functional Genotnics. 2nd edition, John Wiley and Sons, New Jersey.
7. Attwood T. K and Smith D. J. P., 1999, Introduction to Bioinformatics. Pearson Education Limited, England.
8. Waterman M.S., 1995, Introduction to Computational Biology: Maps, Sequences and Genomes. Waterman Chapman and Hall/ CRC Press ISBN -10: 0412993910.
9. Wayne W. D., 1999, Biostatistics: A Foundation for Analysis in Health Sciences, John Wiley and Sons.

MBE 901: Phycology and Mycology

Max.Marks : 100

Unit-I

General characters and classification of algae; Important features, asexual and sexual reproduction in representative genera of Chlorophyceae (*Chlamydomonas, Spirogyra &* Dianoflagellates) Pheophyceae (*Ectocarpus & Sargassum*), Bacillariophyceae (Diatoms) and Rhodophyceae (*Polysiphonia)* and Cyanophyceae (*Spiruluna, Anabaena*).

Unit-II

General characters & classification of fungi; Mastigomycotina (*Albugo, Phytothora*), Zygomycotina (*Rhizopus*), Ascomycotina (*Sacchromyces & Neurospora*), Basidiomycotina (Puccinia *& Agaricus*) and Deuteromycotina (*Cercospora & Colletorichum*); Unique characteristics of filamentous fungi that are advantageous for genetic analysis (Parasexual analysis,gene silencing): Ascomycetes yeast (*S.crevisae*), Ascomycetes filamentous fungi (*Neurospora crassa* and *Aspergillus nidulans*) & Basidiomycetes filamentous fungi (*Coprinus cinereus*).

Unit-III

Economic importance of algae: Algae as pollution indicator, eutrophication agent and its role in bioremediation; algae in global warming and environmental sustainability; cyanobacteria and selected microalgae in agriculture-biofertilizer and algalization.

Dy. Registrar
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JAIPUR

Unit-IV

Lichens: Structure, relationships, reproduction, ascolichens, basidiolichens, deuterolichens, Mycorrhiza: ecto-, endo-, ectendo- VAM; Fungi as insect symbionts & biocontrol agent, fungi attack on other microorganisms; Economic importance of fungi.

Mycoses infections: Structure, Genome, dimorphism, pathogenesis & treatment

(a) Superficial mycoses (*Microsporum*, *Trichophyton*, *Epidermophyton*, *Pityrosporon orbiculare*, *Candida albicans*, *Piedraia*)

(b) Cutaneous mycoses (*Sporothrix schenckii, Epidermophyton, Lophophyton, Microsporum, Nannizzia, Trichophyton, Candida albicans and related species, Neoscytalidium dimidiatum, Scopulariopsis brevicaulis*).

Practicals:

1. Fungi cultivation methods.
2. Study of mycorrhizae.
3. Study of lichens.
4. Study of representative algae listed in syllabus.
5. Cultivation and morphology of molds.
6. Identification of fungi and molds from food samples.
7. Study of representative fungi listed in syllabus.
8. Spore print of mushrooms.
9. Use of algae for biofuel production.
10. **Slides as per syllabus.**

Note: Photographs may be supplemented wherever required.

Suggested Books:

1. Atlas R.M., 1997, Principles of Microbiolgy. 2nd edition, MC Graw Hill.
2. Barsanti L. and Gualtieri P., 2006, Algae: Anatomy, Biochemistry and Biotechnology. Taylor and Francis Group, LLC.
3. Chatterjee K.O., 1999, Parasitology. Calcutta Publication.
4. Lee R.E., 1999, Phycology. 3rd edition, Cambridge University Press, Cambridge.
5. Nester E.W., Anderson O.G. and Nester M.T., 2006, Microbiology: A Human Perspective. Mc Graw Hill.

Dy. Registrar
(Academic)
University of Rajasthan
JAIPUR

6. Prescott L.M., Harley J.P. and Klein D.A., 2007 Microbiology. 7th edition, Mc Graw Hill.
7. Talaro K.P. and Talaro A., 2006, Foundations in Microbiology. Mc Graw Hill.
8. Wilfey J., Sherwood, L. and Woolverton C., 2007, Prescott Harley/ Klein's Microbiology. McGraw Hill.

MBE 902: Genetic Engineering

Max. Marks -100

Unit I

Basics of recombinant DNA technology: Enzymes used in recombinant DNA technology: Nuclease, DNA ligase, polymerase, reverse transcriptase, terminal deoxy-nucleotidyl transferase, alkaline phosphatise; Modification of restriction fragment ends: Sticky and blunt end ligation with linkers & adapters and homo-polymer tailing.

Unit-II

Cloning vectors: Properties of plasmids, yeast plasmid (YAC), binary & shuttle vectors, bacteriophages, cosmids, bacterial artificial chromosomes, Ti based vectors, Expression of vectors – use of promoters and expression cassettes; Bacculovirus as expression vector, retroviruses; Isolation and purification of genomic and plasmid DNA; Gene libraries: Genomic library, screening of libraries (shot gun approach) & cDNA library.

Unit –III

Introduction of recombinant vectors into bacterial and non bacterial cells; Selection of recombinant clones; Colony hybridization, Plaque hybridization, immunochemical methods; Application of genetic engineering: Scientific, medical, industrial, agricultural and environmental applications; mechanism of CRISPER-CAS technology & application; Human genome project.

Unit-IV

Polymerase chain reaction (PCR): Basic principle, components of PCR, PCR techniques: Standard PCR, Inverse PCR, reverse transcriptase mediated PCR, Anchored PCR, Asymmetric

PCR & Real time PCR, PCR for mutagenesis; molecular DNA sequencing: dideoxy method (Sanger sequencing), Chemical degradation (Maxum-Gilbert method); Strategies for sequencing large DNA fragments; Automated sequencing and pyro sequencing; Molecular markers –types and applications, DNA chip technology , microarrays, Brief description of Probes: Types; RFLP, AFLP and RAPD; Southern, Western and Northern blotting.

Practicals:

1. Isolation of bacterial genomic DNA.
2. Visualization and documentation of bacterial genomic DNA using gel doc system.
3. Restriction digestion and ligation of bacterial genomic DNA.
4. Recovery of genomic DNA embedded in Agarose gels (freeze squeeze, column).
5. Amplification of DNA by PCR techniques.
6. Plasmid preparation from *E.coli.*
7. Analysis of Plasmid on agarose gel electrophoresis.
8. SDS PAGE- Bacterial proteins.
9. Demonstration of Southern hybridization technique.

Suggested Books:

1. Adams M.R and Moss M.O., 1995, Food Microbiology, Royal Society of Chemistry Publications, Cambridge.
2. Alberts B., Johnson A., Lewis J., Raff M., Roberts K. and Walter P., 2007, Molecular Biology of the Cell, 5th Edition, Garland Science, New York and London.
3. Banwart G.J., 1993, Basic Food Microbiology, CBS Publishers and Distributors, Delhi.
4. Berg J.M., Tymoczko J.L. and Stryer L., 2008, Biochemistry, 5th Edition, Freeman W.H. and Company New York, USA,
5. Cruegar W. and Cruegar A., 1990, Biotechnology: A textbook of industrial microbiology, 2nd Edition, Sinauer Associates .Inc.
6. Frazier W.C. and Westhoff D.C., 1998, Food Microbiology, Tata Mc Graw Hill Publishing Company Ltd, New Delhi.
7. Hobbs B.C and Roberts D., 1993, Food poisoning and Food Hygiene, 6th Edition Edward Arnold (A division of Hodder and Stoughton, London).
8. Jay J.M., 1992, Modern Food Microbiology, 4th Edition, Van Nostraand Reinhold Co., New York.
9. Lewin B., 2007, Gene IX, Jones and Bartlett Publishers, Sudbury, Massachusetts.

Dy. Registrar
(Academic)
University of Rajasthan
JAIPUR

10. Robinson R.K., 1990, Dairy Microbiology, Elsevier Applied Sciences, London.
11. Stanburg P.E., Whittaker A. and Hall S.J., 1995, Principles of fermentation technology, 2nd Edition, Pergamon Press.
12. Watson J.D., Baker T.A., Bell S.P., Gann A., Levin M. and Losick R., 2007, Molecular Biology of the Gene, 6th Edition, Benjamin Cummings, San Francisco, USA.
13. Weaver R.F., 2007, Molecular Biology, 4th Edition, McGraw Hill, New York, USA.

MBE 903: Dissertation

Max.Marks: 100

The dissertation work would involve practical work on a selected problem. It should include:

1. Introduction
2. Review of Literature
3. Materials & Methods
4. Results (Statistically analyzed if required)
5. Discussion
6. Conclusion
7. References

- **For evaluation- the dissertation will be sent to External examiner/s.**
- **Presentation and Viva- Voce of this paper would be a part of the elective practical MBE 912.**

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University of Rajasthan
JAIPUR

Syllabus M.Sc Microbiology

Semester IV

MBC 1001: Immunology

Max.Marks : 100

Unit I

1. Historical background; Innate immunity, Adaptive immunity (cell mediated and humoral), Natural and artificial immunity;Active and Passive immunity, Barriers to infection; Phases of Immune responses; Clonal selection hypothesis.
2. Hematopoiesis; Cells of immune system; Lymphoid organs-Primary and Secondary.
3. Immunoglobulin-General structure, Ig isotypes, structure and function.

Unit II

1. Antigens-Properties, Types (Isotypes, Allotypes, Idiotypes), Antigen specificity, superantigen, Determinants-linear, conformational and neo-antigenic, Haptens, Adjuvants
2. Characteristics of primary antigen- antibody interactions; antigen-antibody interactions (Precipitations, Agglutinations, RIA, ELISA, Immunoelectrophoresis, Crossed antigen-antibody electrophoresis, Western blotting etc).
3. Complement pathways (Classical, alternative and lectin), Biological significance and deficiencies.
4. Hybridoma technology-monoclonal antibodies and its applications; Production of polyclonal antibody and its application.

Unit III

1. Mechanism of cell mediated and humoral immunity.
2. MHC types and structure, Exogenous and endogenous antigen capture and presentation to the lymphocytes, Cross presentation of exogenous antigens.
3. Vaccine-Route of immunization, Natural immunization schedule, Types: attenuated and inactivated vaccine, synthetic peptide, DNA vaccine, Recombinant vaccine, subunit vaccine, idiotype based vaccine, glycoconjugate vaccine, ISCOM's and plantibodies , vaccine delivery system.

4. Immunity to microbes: Bacteria, Fungi, Virus and Helminthes, Pathogen recognition receptor (PRR) and Pathogen Associated Molecular Pattern (PAMP).

Unit IV

1. Cytokine (Properties, receptors, cytokine related disease and cytokine -based therapy), Hypersensitivity (Classification, types and disease).
2. Autoimmune diseases- Addison's disease, Graves' disease, Hasimoto's thyroidites, autoimmune haemolytic anemia; rheumatoid arthritis, Goodpasture's syndrome, Sjögren's syndrome.
3. Immune deficiencies-B cell deficiencies (X-linked agamma globulinemia, X-linked hyper-IgM syndrome); T cell deficiencies (22q11 deletion syndrome, CD8 deficiency); B and T cell deficiencies (Common γ chain deficiency, ADA deficiency).

Practicals:

1. Dissect, localize and study the structure of lymphoid organs (Demonstration and detailed study).
2. Preparation of antigen and routes of immunization.
3. Generation of antibody in mice/rat/rabbit/guinea pig and sample collection (retro-orbital and heart).
4. Blood smear preparation & Identification of different WBC.
5. Differential Blood Counts- WBC & RBC.
6. Agglutination: Widal test.
7. Precipitation.
8. Ouchterlony's double diffusion.
9. Radial Immunodiffusion.
10. Immunoelectrophoresis: RIE.
11. ELISA.
12. Viability and cell counting of peritoneal macrophages using trypan blue.
13. Slides: Spleen, thymus, lymph node, ileum- Peyers patch, Blood cell type's identification.

Note : (a) Photographs to be supplemented on unavailability of slides.
(b) Slides from experiments.

Suggested Books:

1. Abbas A.K., Lichtman A.H., Pillai, S. and Saunders, 2007, Cellular and Molecular Immunology. Elsevier.
2. Benjamin, 2004, Immunology- A short course.

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JAIPUR

3. Claus C., 1996, Immunology- Understanding of Immune System. Wiley, New York.
4. Delves P.J., Martin S.J., Burton D.R. and Roitt I.M., 2006, Roitt's Essential Immunology. 11th edition, Blackwell Publishing/Oxford University Press.
5. Kindt T.J., Goldsby R.A., Osborne B.A. and Kuby J., 2006, Kuby Immunology. 6th Edition, WH Freeman, New York.
6. Levinson W. and Jawetz E., 2001, Medical Microbiology and Immunology. Lange Publications.
7. Paul W.E., 2000, Fundamental Immunology. 4th edition, New York. Raven Press.

MBC 1002: Microbial Ecology

Max.Marks : 100

Unit I

Biotic and abiotic environment, Composition and structure of environment.Concept of biosphere, communities and ecosystems. Ecosystem characteristics, structure and function. Liebig's law of minimum, Shelford's law of Tolerance, Food chains, food webs and trophic structures. Ecological pyramids.

Unit II

Inter species interactions in microbes: Antagonism, competition, commensalisms, synergism, parasitism and predation. Gansse's and Hardin's principles of competition.
Beneficial interactions of microbes with animals: Rumen microbiology, digestion, fermentation and detoxification by microbes, factors influencing rumen microbes.
Beneficial interactions of microbes with plants: Rhizosphere, rhizoplane, siderophore, Biofertilizer: types and applications; Mycorrhizae: classification and significance.

Unit III

Role of microbes in biogeochemical cycles: Carbon cycle, Nitrogen Cycle, Phosphorus cycle, Sulphur cycle, Iron and Manganese cycle. Environmental impact of biogeochemical cycles.Eutrophication: Definition, causes of eutrophication and microbial changes in eutrophic bodies of water induced by various inorganic pollutants. Effects of eutrophication on the quality

of water environment, factors influencing eutrophication, Algae in eutrophication, algal blooms, their effects and toxicity. Physico-chemical and biological measures to control eutrophication.Corrosion by microbes,desuphurization of coal.

Unit IV

Microorganism in the ecosystem(air,soil and water), Soils profiles, major physiochemical and biological characteristics, soil microflora: distribution and contribution to ecosystem. Assessment of air quality for microbial loads; Brief account of air borne transmission of microbes - viruses - bacteria and fungi, their diseases and preventive measures. Microbial assessment of water quality, potability of water, microbes as bio-indicators, brief account of major water borne diseases and their control measures, treatment of municipal water, Microbial pest control, Biofilm formation and its ecological implication. Metagenomic approaches for the identification of microorganisms.

Practicals:

1. Isolation and identification of air borne microbes –Indoor & outdoor.
2. Isolation and identification of soil microflora.
3. Determination of soil texture and Humic acid.
4. Isolation and identification of microbial flora of water.
5. Soil microbes interaction *in vitro* by dual culture method.
6. Isolation, identification and enumeration of Rhizosphere and Rhizoplane microrganisms.
7. Isolation of Rhizobium from roots of leguminous plant.
8. **Slides as per syllabus.**

Suggested Books:

1. Agate, A. D., 1982, Basic Principles of Geomicrobiology, MACS, Pune.
2. Atlas R.M. and Bartha R.,1998, Microbial Ecology: Fundamentals and Applications..4th edition, Benjamin /Cummings.
3. Baker K.H. and Herson D.S., 1994, Bioremediation. McGraw Hill Inc. N.Y
4. Barton L. L. and Northup D. E.,2011, The Microbial Habitat: An Ecological Perspective. Wiley.
5. Barton L.L. and Northup D.E., 2011, Microbial Ecology. Wiley-Blackwell.

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6. Bertrand J-C.,Caumette, P.,Lebaron P.,Matheron R., Normand P. and Sime –Ngando T., 2015, Environmental Microbiology: Fundamentals and Applications. Microbial Ecology. Springer, Netherlands.
7. Campbell, R.,1983, Microbial Ecology. Blackwell.
8. Connell, D.W. and Miller, G.J. (Eds.) ,1984, Chemistry and Ecotoxicology of pollution. Wiley Interscience Publications.
9. De A.K, Environmental chemistry, Wiley Eastern Ltd., New Delhi
10. Forster, C. F. and Wase, D.A.J. (Eds.),2001, Environmental Biotechnology. Ellis Harwood Ltd. Publication. Longman Inc California.
11. Madigan M. T., Martinko J. M., Bender K. S., Buckley D. H., Stahl D. A., Brock T., 2014, Brock's Biology of Microorganisms. 14th edition, Pearson.
12. Maier R.M., Pepper I.L. and Gerba C.H., 2009, Environmental Microbiology. Academic Press, Elsevier.
13. Maier, R.M., Pepper, I.L. & Gerba, C.P.,2009, Environmental Microbiology. 2nd Ed. Academic Press.
14. Mitchell, R.,1992, Environmental Microbiology. John Wiley & Sons.
15. Oladale O., 2005, Microbial Diversity. Blakewell Publishing.
16. Osborn M. and Smith C., 2005, Molecular Microbial Ecology. Taylor & Francis.
17. Richards, B.N., 1987, Microbes of Terrestrial Ecosystem. Longman.
18. Ronalds M, Atlas Microbial Ecology: Fundamentals and applications, , fourth edition, Animprint of Addison Wesley
19. Trivedy, R. K., 1998, Advances in Waste Water Treatment Technologies. Volumes I and II, Global Science Publication.
20. Wicket, L. P. and Hershberger, C. D., 2000, Biocatalysis and Biodegradation: Microbial transformation of organic compounds. ASM Publications.

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MBC 1003: Industrial Microbiology

Max.Marks : 100

Unit:I

Historical account of microbes in industrial microbiology; Components of a fermentation process; Sources and characters of industrially potent microbes: their isolation, primary and secondary screening and purification; Strain improvement for the selected organism: mutation and screening of improved cultures, random and strategic screening methods; Microbial growth kinetics in batch, continuous and fed batch fermentation process; Preservation and maintenance of microbial cultures.

Unit: II

Types of fermentation processes; Solid state and submerged fermentations: their advantages and disadvantages; Design of a basic fermenter: bioreactor configuration, design features, individual parts: baffles, impellers, foam separators, sparger, culture vessel, cooling and heating devices, probes for on- line monitoring, computer control of fermentation process; Factors affecting fermentation process (pH, aeration, agitation , temperature, etc);Types of Bioreactor: Stirred tank reactor, Bubble column reactor, Airlift reactor, Packed bed reactor, Fluidized bed reactors, Photo-bioreactors; Raw materials used in industrial fermentation media. Media formulation, sterilization and optimization.

Unit III

Immobilisation of microbial enzymes and whole cells and their applications in industries; Downstream processing; Production of recombinant molecules in heterologus system, various steps for large protein purification; Brief idea of Patenting: Concept and its composition & protection of right and their limitation and intellectual property rights (IPR).

Unit IV

Microbial commercial production of organic acids (citric acid); amino acids (glutamic acidand lysine);vitamin (vitamin B12) ;Industrial enzymes (cellulases, xylanases, amylases and proteases and their applications);Biofuels (ethanol and methane) from organic residues; Biomass (Baker's Yeast and Single Cell Proteins);Antibiotics (penicillin); Biofuels (Ethanol and Methane); Recombinant proteins (Insulin).

Practicals:

1. Study of growth curve of microorganism/s.
2. Production of Baker's yeast.
3. Primary Screening techniques (crowded plate).
4. Secondary screening techniques.
5. Amino acid production using *E. coli* mutant strains.
6. Use of growth & production media for citric acid production.
7. Isolation of industrially important microorganisms for amylase production.
8. Isolation of protease producing microorganisms.
9. Enzyme immobilization.
10. Production of biofuels by microorganism/s.

Suggested Books:

1. Casida L. E. J. R., 2015, Industrial Microbiology. New Age International, New Delhi
2. Crueger W and A. Crueger., 1991, Biotechnology. A Textbook of Industrial Microbiology, Sinauer Associates.
3. Reed G., Prescott S. C., Dunn C. G.,1987,Prescott and Dunn's Industrial Microbiology.4th edition CBS ,New Delhi.
4. Shuler M.L. and F. Kargi., 2001,Bioprocess Engineering Basic Concepts.(Prentice-Hall International Series in the Physical and Chemical Engineering Sciences) Prentice Hall.
5. Stanbury P. F.Whitaker, A and Hall S. J., 2003, Principles of Fermentation Technology.2nd edition, reprinted. Butterworth-Heinemann.
6. Vogel H.C., Todaro, C.L and Todaro. C.C., 1997, Fermentation and Biochemical Engineering Handbook: Principles, Process Design, and Equipment. Noyes Data Corporation / Noyes Publications.

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MBE 1001: Genomics and Proteomics

Max.Marks : 100

Unit 1

Genome, genomics, Omics and importance; Structural organization of Prokaryotic and eukaryotic genomes; Evolution and structure of mitochondrial genomes; gene identification, Genome databases, genome diversity: Taxonomy and significance of genomes –bacteria, yeast, *Caenorhabditis*, *Homo sapiens* and *Arabidopsis*; Repetitive and transposable elements and their significance in the genome: Tandemly repeated DNA and interspersed genome-wide repeats; DNA and RNA Transposons.

Unit II

Genetic and Physical mapping: Linkage and Pedigree analysis, Markers: Genes, Restriction fragment length polymorphisms (RFLPs), Simple sequence length polymorphism (SSLP's), Amplified fragment length polymorphism(AFLP), Variable number tandem repeat (VNTR), Single nucleotide polymorphisms (SNPs), Restriction mapping, Fluorescent *in situ* hybridization (FISH), Sequence tagged site (STS),DNA finger printing, Radiation hybrid mapping; Genome Project – Human Genome project, Hap Map project, the 1000 genome project, The ENCODE project, Structural genomics – Assembly of Contiguous DNA sequences- Shot gun method, Clone Contig method and whole genome shotgun sequencing.

Unit III

Protein structure - four levels of organization; Cellular functions performed by proteins; Introduction of proteomics; Protein analysis (concentration, amino acid composition, N- terminal sequencing),Strategies for protein extraction, solubilization, identification and separation: ion-exchange, size-exclusion and affinity chromatography techniques; Polyacrylamide gel electrophoresis; Isoelectric focusing (IEF); Two dimensional PAGE for proteome analysis; Peptide fingerprinting, , Electro Spray Ionization(ESI), LS/MS-MS for identification of proteins and modified proteins, Mass spectroscopy (MALDI-TOF),SAGE and differential display of proteins and modified proteins. Mass finger printing (PMF), 3D structure determination by X-ray and NMR; Protein identification programme – MASCOT, PeptIdent and Protein prospector.

Unit IV

Biological data bases (Classification: Primary secondary and composite, Nucleotide sequence), Interactomics: Techniques to study protein-protein interactions (Two hybrid interaction screening); Bacterial protein meta-interactomes predict cross-species interactions and protein function; Viral interactomes; Overview of front-line techniques within the field of proteomics: Microarray techniques, Advantage, disadvantage and application of protein microarray, Databases and handling of sequence data, pair-wise alignment, multiple alignment, the portals SRS and Entrez; Computational methods to study interactomes;Clinical and biomedical application of proteomics.

Practicals:

1. Study of Bacterial genome atlas BacMap.
2. Study of retro-transposons.
3. Cot and Rot curve analysis.
4. Ion-exchange chromatography.
5. Size-exclusion chromatography.
6. Affinity chromatography.
7. SDS-Polyacrylamide gel electrophoresis.

Suggested Books:

1. Brown TA., 2006, Genome III .Garland Science Publishers.
2. Campbell, A.M., Heyer L.J. and Benjamin C., 2007 Discovering Genomics, Proteomics and Bioinformatics. 2nd edition. Cold Spring Harbor Lab Press, NY.
3. Lesk A.M., 2007, Introduction to Genomics. Oxford University Press.
4. Liebler D C., 2002, Introduction to Proteomics: Tools for the New Biology, Humana Press Inc.,
5. Lovric J., 2011, Introducing Proteomics. 1st edition, Wiley-Blackwell.
6. Nelson, T D. and Fraser K E., 2004, Microbial Genomes. Humana Press, Inc .,USA
7. Pevsner J., 2009, Bioinformatics and Functional Genomics. 2nd edition, Wiley-Blackwell.

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MBE 1002: Agriculture Microbiology

Max.Marks : 100

Unit: I

Soil microorganisms in agro ecosystems: Types of microbial communities; soil microbial diversity: significance and conservation; Effect of agricultural practices on soil organisms; Chemical transformation by microbes: Organic matter decomposition, nutrient mineralization and immobilization; Transformation of carbon and carbon compounds; Availability of phosphorus, sulfur, iron and trace elements to plants; Biological nitrogen-fixation: Rhizobium-Legume Association; N_2 fixation by non-leguminous plants; Microbial products and plant health: PGPR (plant growth promoting rhizobacteria); significance of mycorrhizae; toxin producing microbes (antibiotics, aflatoxin).

Unit: II

Microbial biofertilizers and biopesticides: Production of bacterial biofertilizer: *Azospirillum, Azotobacter, Bacillus, Pseudomonas, Rhizobium and Frankia*; cyanobacterial biofertilizers: *Anabaena, Nostoc, Hapalosiphon*; Mycorrhizal biofertilizers: mycorrhizae - ecto and endo mycorrhizae and their importance in agriculture; Algal and other biofertilizers; Biofertilizers: aiding in phosphorus nutrition; Regulation of ethylene production in roots, Secondary metabolite production; Production of microbial herbicides: bacterial insecticides, viral insecticides, entomopathogenic fungi & microbial nematodes.

Unit III

Disease forecasting and basic principles of plant disease control: Pathology, etiology and control of economically important crop diseases of wheat (Rust, smut), paddy (Blast),barley (Smut), bajra (Ergot), maize(Downy mildew), sugarcane (Red rot), potato (Late blight and early blight) caused by fungi; Management & storage of agricultural products, post harvest diseases, their prevention and control.

Unit IV

Microbial interactions in animals: Rumen microbiology, microbial contribution to food digestion; Microbial diseases of farm animals (Anthrax, fowl cholera), their prevention and

control, Role of bacteria in agriculture, scavenging, nitrifying, saprophytic, ensilage, fuel producing and decomposing; Quorum sensing bacteria; Principles and mechanism of biological control; Commercial production of bio-pesticides with reference to *Bacillus thuringiensis*.

Practicals:

1. Isolation and enumeration of bacteria and fungi from soil samples.
2. Rhizosphere micro-organisms.
3. Physico-chemical testing of soil.
4. Microbes in composting.
5. Study of anatogonism of micro-organism by dual culture inoculation method.
6. Commercial production of bio-fertilizers.
7. Standard ISI regulations for mass cultivation of bio-fertilizers.
8. Crop diseases caused by fungi listed in the syllabus.
9. Diseases of farm animal (any two).
10. Pheromones traps.
11. Slides as per syllabus.

Suggested Books:

1. Agrios G.N., 1997, Plant Pathology. Academic Press, San Diego.
2. Basu A.N. and Giri B.K., 1993, The Essentials of Viruses, Vectors and Plant Diseases. Wiley Eastern Ltd.
3. Glick B. R., Holguin G, Patten C. L., 1999, Biochemical and Genetic Mechanisms Used by Plant Growth and Bacteria. Imperial College Press.
4. Black J.G., 2008, Microbiology : Principles and Explorations. 7th edition, International Student Version edition. John Wiley & Sons.
5. Christen J.H., 2001, A Manual of Environmental Microbiology. ASM Publications.
6. Cook R.J. and Baker K.F., 1983, The Nature and Practice of Biological Control of Plant Pathogens. America Phytopathological Society Press, St. Paul, MN.
7. Cooper J. E. and Rao J. R., 2007, Molecular Approaches to Soil, Rhizosphere and Plant Microorganism Analysis. CABI Publication.
8. Dickinson M., 2003, Molecular Plant Pathology. BIOS Scientific Publishers, London.
9. Froster C.F. and John D.A., 2000, Environmental Biotechnology. Ellis Harwood Publications.
10. George N. A., 1997, Plant Pathology. 4th edition, Academic Press, New York.

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11. Kahn M. S., Zaidi A. and Mussarrat J., 2009, Microbes in Sustainable Agriculture. Nova Science Publishers
12. Liong Min-Tze., 2015, Beneficial Microorganisms in Agriculture, Aquaculture and Other Areas (Microbiology Monographs). 1st edition. Springer.
13. Lopez- Real J.M. and Hodges R.D., 1986, Role of Microorganisms in a Sustainable Agriculture. AB Academic Publishers
14. Rao N.S.S., 1999, Soil Microbiology. Oxford & ISH Publishing Co., New Delhi.
15. Sigee D.C., 1993, Bacterial Plant Pathology, Cell and Molecular Aspects. Cambridge University Press.
16. Subbarao N.S and Dommergues Y. R., 2000, Microbial Interactions in Agriculture and Forestry. v. 2 Science Publishers U.S.
17. van Elsas J. D and Trevors J. T., 2006, Modern Soil Microbiology. 2nd edition, CRC Press / Taylor and Francis Group

MBE 1003: Clinical and Pharmaceutical Microbiology

Max.Marks : 100

Unit I:

Specimen collection and processing: Basic principles of specimen collection (blood, sputum, urine, stool, CSF, vaginal smears etc), preparation of container and swabs for collection of specimens for microbiological examination, preservation storage and transport of specimens, documentation of specimen. Microbiological examination of clinical specimens: Microscopic examination, use of colonial morphology for presumptive identification, biochemical identification of micro organisms. Role of microbiological diagnosis and control of infections, Application of molecular diagnostics: Nucleic acid hybridization, nucleic acid amplification.

Unit II:

(a) Clinical syndromes and their laboratory diagnosis: Upper and Lower respiratory tract infections (Pharyngitis & pneumonia), Skin and soft tissue infection (Impetigo, folliculitis, furuncle, carbuncle, cellulites and erysipelas), Infection of central nervous system (Meningitis and Encephalitis); Sexually transmitted diseases, Sexually acquired Zika virus, Hantavirus, Ebola, Mad cow disease, Anthrax; Infection in special populations (Malignancy, AIDS, Tuberculosis and leprosy).

(b) Epidemiology, surveillance and control of community and hospital infections. Antimicrobial chemotherapy, emergence of drug resistance (MRSA, ESBL and MDR TB). Methods of prevention and control- isolation of patients, quarantine and incubation period of various infectious diseases. Management of patients in infectious disease hospital. Determination, management, safety and quality control in medical microbiology laboratory, Laboratory response to bioterrorism.

Unit – III

(a) Antibiotics and synthetic antimicrobial agents (Aminoglycosides, β lactams, tetracyclines, ansamycins, macrolid antibiotics); Antifungal antibiotics; Antitumor substances; Peptide antibiotics; Chloramphenicol, Sulphonamides and Quinolinone antimicrobial agents; Chemical disinfectants, antiseptics and preservatives.

(b) Mechanism of action of antibiotics (inhibitors of cell wall synthesis, nucleic acid and protein synthesis)and bacterial resistance to antibiotics; Molecular principles of drug targeting; Drug delivery system in gene therapy; Mode of action of non – antibiotic antimicrobial agents; Penetrating defenses – How the antimicrobial agents reach the targets (cellular permeability barrier, cellular transport system and drug diffusion).

Unit – IV

(a) Microbial production and Spoilage of Pharmaceutical Products; Pharmaceuticals produced by microbial fermentations (streptokinase, streptodornase); Microbial contamination & spoilage of pharmaceutical products (sterile injectibles, non injectibles, ophthalmic preparations and implants) and their sterilization; Macromolecular, cellular and synthetic drug carriers; New vaccine technology, DNA vaccines, synthetic peptide vaccines, multivalent subunit vaccines and Vaccine clinical trials.

(b) Regulatory practices and applications in Pharmaceuticals; Elementary idea of IP, BP and USP; Government regulatory practices and policies and FDA perspective; Rational drug design;Regulatory aspects of quality control; Quality assurance and quality management in pharmaceuticals ISO, WHO and US certification; Sterilization control

and sterility testing (heat sterilization, D value, z value, survival curve, Radiation, gaseous and filter sterilization) and Chemical & biological indicators.

Practicals:

1. Collection, transport and preservation of different clinical specimens (Sputum, CSF, blood, urine, stool and swabs from different sites of infection).
2. Isolation and identification of micro organism from different clinical specimens.
3. Detection of malaria parasite from blood sample.
4. Detection of ova/cyst from stool sample (Parasites).
5. Effect of disinfectants and antimicrobial agents on microbes/microbial growth.
6. Identification of *Candida* by microscopical examination (Staining and germ tube formation) and cultural characteristics.
7. Rapid detection tests:

   (i) Dip stick test for detection of malaria parasite.

   (ii) DOT EIA for detection of typhoid fever.

   (iii) Comb assay for detection of *Mycobacterium tuberculosis.*

8. Spectrophotometric / Microbiological methods for the determination of Griesofulvin.
9. Bioassay of chloremphenicol by plate assay method or turbidiometric assay method.
10. To determine MIC, LD_{50} of Beta-lactum /amino-glycoside/ tetracycline/ansamycins.
11. Sterility testing by *Bacillus* stearothermophilus.
12. Sampling of pharmaceuticals for microbial contamination and load (syrups, suspensions, creams and ointments, ophthalmic preparations).
13. Determination of D value, Z value for heat sterilization in pharmaceuticals

Note: Photographs may be supplied wherever required.

Suggested Books:

1. Jorgensen , J. H, . Pfaller, M. A, Carroll, K. C, Funke, G, Landry, M L, Richter, S S, . Warnock D W., 2015, Manual of Clinical Microbiology, Eleventh Edition, American Society Microbiology.

2. Forbes B A., Sahm, D F., Weissfeld, A S., 2017, Bailey & Scott's Diagnostic Microbiology Betty A Forbes, Daniel F Sahm, Alice S Weissfeld. Mosby Year Book Inc.
3. Carroll, K C. , Hobden, J A., Miller S. , Morse A S., Mietzner A T., Detrick B. , Mitchell T G. , McKerrow JH., Sakanari J A., 2013, Jawetz, Melnick, & Adelberg's Medical Microbiology 27th edition (Lange basic), McGraw-Hill
4. Mukerjee, K., 2003, Medical Laboratory Technology. Tata McGraw Hill Publishing Company Limited, New Delhi.
5. Murray P R., Manual of Clinical Microbiology, American Society Microbiology
6. Nagoba BS., 2009, Clinical Microbiology, Bi Publications Pvt Ltd
7. Ryan K. and Ray C. G., 2004, Sherris Medical Microbiology: An Introduction to Infectious Diseases. 4th edition. McGraw-Hill Medical
8. Sood, R., 2004, Medical Laboratory Technology Methods and Interpretations. Jaypee Brothers Medical Publishers (P) Ltd. New Delhi.

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