



**SHRI JAGDISHPRASAD JHABARMAL TIBREWALA
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SEMESTER-I

PAPER –I GENERAL MICROBIOLOGY

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 Archaeobacteria & Cyanobacteria, 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, Nitrosomonas, Clostridium, Lactobacillus, Streptococcus & Staphylococcus.*

Fungi : *Saccharomyces cerevisiae, Dictyostellum discodium, Penicillium & Candida albicans.*

Algae : *Diatoms & Dinoflagellates.*

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

Practicals:

1. Identification of various bacteria.
2. Identification of various algae.
3. Identification of various fungi.
4. Identification of various protozoans (Free living & Parasitic protozoa).
5. Identification of Cyanobacteria.

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.

PAPER –II TECHNIQUES IN MICROBIOLOGY

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 fluorescent 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

Principal and theory of biochemical activities of the microorganisms: Triple sugar –Iron agar test, ImVic test, Methyl red test, Citrate utilization 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, compound & phase contrast.
(b) Micrometry.
3. Media preparation: Liquid & solid and Sterilization.
4. Streak plate technique, Pour plate technique & Spread plate technique.
5. Use of selective and differential medium; Use of indicator media.
6. Aerobic / Anaerobic cultivation.
7. Cultural characteristics of microorganisms; Preservation of cultures.
8. Biochemical tests-Catalase test, Triple sugar –Iron agar test, ImVic test & Methyl red test.

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

PAPER –III MICROBIAL BIOCHEMISTRY

Unit-I

Chemical properties of water: ionization and acid base chemistry; Carbohydrates- classification; configuration and conformation of monosaccharides, disaccharides polysaccharides,(structural–cellulose,peptidoglycan,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; 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 & Protein.
2. Quantitative estimation of total proteins (Lowry *et al.*, method).
3. Quantitative estimation of blood glucose & glycogen.
4. Quantitative estimation of lipids & total cholesterol.
5. Quantitative estimation of DNA & RNA.
6. Quantitative estimation of any enzyme.
7. Quantitative estimation of polyphenol & carotenoids.
8. 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.
11. Talaro K.P. and Talaro A., 2006, Foundation in Biochemistry, 6th Edition, Tata McGraw Hills.

PAPER –IV BIOSTATISTICS

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, Personalistic & 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
- 5.5 Students t-test (Unpaired & Paired)
- 5.6 F-test (Variance ratio)

6. Analysis of Variance

- 6.1 One way classification
- 6.2 Two way classification

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)
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, chi-square test, one way and two way ANOVA.
5. Use of M.S. Word.

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 Est-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 Cochran W.G., 1968, Statistical Methods, Oxford & IBH, Delhi.
10. Tramontano A., 2007, Introduction to Bioinformatics, Chapman & Hall/CRC.



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SEMESTER-II

PAPER –I BACTERIOLOGY

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, chemoheterotrophs, 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. Cultivation of microorganisms- nutritional & physical requirements.
2. Quantitation of viable cells in bacterial culture.
3. Growth dynamics of bacterial culture.
4. Micrometry of bacterial cells.
5. Study of microorganism morphology: Hanging drop method and wet mount.
6. Preparation of bacterial smears.
7. Simple staining & Negative staining.
8. Differential staining –Gram staining, Acid –Fast staining & Spore staining.
9. Biochemical : Carbohydrate fermentation & Citrate utilization test.

Suggested Books :

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

PAPER –II MICROBIAL METABOLISM & PHYSIOLOGY

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.

Unit-II

Respiratory metabolism: Glycolytic pathway of carbohydrates breakdown, glycolysis, (Embden Meyerhoff pathway), Krebs's cycle and Entner – Doudoroff 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 TSIA 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. Fermentation of carbohydrates.
7. Study of chemolithotrophs.
8. Litmus milk-homo-fermentation/ hetero-fermentation.
9. Effect of temperature and pH on bacterial growth.
10. Determination of microbial 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 L., 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.

PAPER –III MEDICAL MICROBIOLOGY

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.

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: *Cryptococcus neoformans*, *Blastomyces dermatitidis*, *Trichophyton*, *Histoplasma capsulatum*, *Coccidioides immitis*, *Candida albicans*, *Aspergillus fumigatus*, *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. Laboratory rules and regulation in pathological laboratory.
2. Collection of specimen –Basic concepts, Transport containers for anaerobic specimens & collection.
3. Techniques for transfer of clinical specimens & selection of primary culture media, Interpretation of culture.
4. Identification based on metabolic characteristics.
5. Antibiotic susceptibility testing.
6. New Technologies in the laboratory diagnosis of infectious diseases.

Suggested Books :

1. Baron S. *Medical Microbiology*, 4th ed. Galveston (TX) 1996.
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*, 5 edition
4. Kenneth J. Ryan, MD; Sean Elliott, MD; Lynn Joens, PhD; Chuck Sterling, BS, PhD (Tucson, AZ) , Paul Pottinger, MD (Seattle, WA) . *Sherris Medical Microbiology*, 6th ed. McGraw-Hill Education , 2014.
5. Murray PR, Rosenthal KS , Kobayashi GS & Pfaller MA . *Medical Microbiology* 8th ed. Mosby Inc. St Louis, Missouri, 2015.

PAPER –IV MOLECULAR BIOLOGY

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, **superhelicity**, 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.

Unit –IV

Regulation of gene expression: Operon concept, negative & positive regulation, inducers, corepressors 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 buffer and solutions.
2. DNA isolation from different cell types-microbes and eukaryotic cell.
3. Check for purity of isolated DNA sample.
4. Quantification of DNA using spectrophotometer.
5. DNA denaturation and determination of T_m and G+C content.
6. Agarose gel electrophoresis of 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.



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SEMESTER-III

PAPER –I VIROLOGY

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 (ϕ X174); 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.
5. Study of retroviruses.
6. Growth of viruses in embryonated eggs.
7. One step growth curve of (ΦX174) virus.
8. Animal cell culture media.
9. Cultivation and maintenance of animal cell lines.
10. Use of suspension /monolayer cell cultures for viral cultivation.

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.

PAPER –II MICROBIAL GENETICS

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 proteins: 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, CRISPER CAS

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.
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.

PAPER –III DAIRY MICROBIOLOGY

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 monocytogenes*, *Mycobacterium*., *Micrococcus*., *Salmonella* spp , *Staphylococcus aureus* & *Yersinia enterocolitica*, *Aspergillus* spp., *Fusarium* spp., *Mucor*, *Penicillium*, *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:

7. Microorganisms in cheese spoilage.
8. Detection of fungal spoilage of dairy products.
9. Contamination in milk.
10. Determination of bacteria number: (a) Standard plate count.
(b) Direct microscopic count.
11. Methylene Blue Reduction Test (MBRT).
12. Turbidity testing for milk.
13. Presumptive test for coliforms in milk & butter.
14. Fermented milk.
15. Biochemical: Litmus milk reactions.
16. Slides as per syllabus.

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.

PAPER –IV PHARMAECUTICAL MICROBIOLOGY

Unit – I

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

Unit – II

Mechanism of action of antibiotics (inhibitors of cell wall synthesis, nucleic acid and protein synthesis); Molecular principles of drug targeting; Drug delivery system in gene therapy bacterial resistance to antibiotics; Mode of action of bacterial killing by quinolones; Bacterial

resistance to quinolones; 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 – III

Microbial production and Spoilage of Pharmaceutical Products; Microbial contamination & spoilage of pharmaceutical products (sterile injectibles, non injectibles, ophthalmic preparations and implants) and their sterilization; Manufacturing procedures and in process control of pharmaceuticals; Other pharmaceuticals produced by microbial fermentations (streptokinase, streptodornase); New vaccine technology, DNA vaccines, synthetic peptide vaccines, multivalent subunit vaccines and Vaccine clinical trials.

Unit – IV

Regulatory practices and applications in Pharmaceuticals; Elementary idea of IP, BP and USP; Government regulatory practices and policies and FDA perspective; Rational drug design; Immobilization procedures for pharmaceutical applications (liposomes); Macromolecular,

cellular and synthetic drug carriers; Biosensors in pharmaceuticals; Application of microbial enzymes in pharmaceuticals; 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. Spectrophotometric / Microbiological methods for the determination of Griesofulvin.
2. Bioassay of chlormphenicol by plate assay method or turbidimetric Assay method.
3. Treatment of bacterial cells with cetrimide, phenol and detection of Leaky substances such as potassium ions, amino acids, purines, Pyrimidines and pentoses due to cytoplasmic membrane damage.
4. To determine MIC, LD₅₀ of Beta-lactum/aminoglycoside/ tetracycline/ansamycins.
5. Sterility testing by *Bacillus stearothermophilus*
6. Sampling of pharmaceuticals for microbial contamination and load (syrups, suspensions, creams and ointments, ophthalmic preparations).
7. Determination of D value, Z value for heat sterilization in pharmaceuticals.
8. Determination of antimicrobial activity of a chemical compound (Phenol, resorcinol, thymol, formaldehyde) to that of phenol under Standardized experimental conditions.

Suggested Books:

1. Cooper M. S., 1973, Quality control in the Pharmaceutical Industry. Vol.2. Academic Press New York.
2. Gregoriadis G., 1979, Drug Carriers in biology & Medicine . Academic Press New York.
3. Hooper D. C and Wolfson J. S., 1989, Quinolone antimicrobial agents. ASM Washington. DC.



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SEMESTER-IV

PAPER –I IMMUNOLOGY

Unit I

1. Historical background; Innate immunity, Adaptive immunity (cell mediated and humoral), Natural and artificial immunity; Barriers to infection; Phases of Immune responses; Clonal selection hypothesis.
2. Hematopoiesis: Cells of immune system; Lymphoid organs-Primary and Secondary.
3. Antigens-Properties, Isotypes, Allotypes, Idiotypes, Antigen specificity, superantigen, Determinants-linear, conformational and neo-antigenic, Haptens, Adjuvants.

Unit II

4. Immunoglobulin-General structure, Ig isotypes, structure and function.
5. Characteristics of primary antigen- antibody interactions; antigen-antibody interactions (Precipitations. Agglutinations, RIA, ELISA, Immunoelectrophoresis, Crossed antigen-antibody electrophoresis, Western blotting etc).
6. Complement pathways (Classical, alternative and lectin), Biological significance and deficiencies; Hybridoma technology-monoclonal antibodies and its applications; Production of polyclonal antibody and its application.

Unit III

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

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

Unit IV

11. Cytokine (Properties, receptors, cytokine related disease and cytokine -based therapy), Hypersensitivity (Classification, types and disease).
12. Autoimmune diseases- Addison's disease, Graves' disease, Hashimoto's thyroiditis, autoimmune haemolytic anemia; rheumatoid arthritis, Goodpasture's syndrome, Sjögren's syndrome.
13. Immune deficiencies-B cell deficiencies (X-linked agammaglobulinemia, 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.
2. Preparation of antigen and generation of antibody in mice/rat/rabbit/guinea pig.
3. Agglutination (Widal test), Precipitation.
4. Ouchterlony's double diffusion, Radial Immunodiffusion, ELISA.
5. Viability and cell counting of peritoneal macrophages using tryptophan blue.
6. Slides: Spleen, Thymus, lymph node, Blood cell types identification; 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.
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.

PAPER –II MICROBIAL ECOLOGY

Unit I

History and scope of microbial ecology; Current perspectives microfossils; Microbial interactions (Within same & diverse populations): (i) Bacteria –Bacterial communication, Quorum sensing in Gram negative bacteria. signaling in Gram positive bacteria; Other types of signaling (ii) interaction of microorganisms with plants, Micorrhizae, Nitrogen fixation in nodules, Interaction with aerial plant structures (iii) microbial interactions with animals ,microbial contribution to nutrition of animals. Commensals and intestinal symbionts and carbon cycle in ruminant animals.

Unit II

Atmoecosphere: Characteristics and stratification of the atmosphere,atmosphere as habitat and **medium** for microbial dispersal; Microorganisms in the atmoecosphere.

Hydroecosphere,Fresh water habitat, Composition and activity of fresh water microbial communities,Marine habitats,Characterisitcs and stratification of the ocean,C_omposition and activity of marine microbial communities.

Microorganisms in soils and rocks;Lithoechosphere;Deep subsurface microbiology.

Unit III

Metagonomics-Cultuyre independent insight;Metagenomic approaches- Sequence based analysis,Functional metagenomics(Heterologous expressions, Identifying active clones— screens, selections and functional anchors) Metagenomics in simple community in acid mine drainage; Ecological inference from Metagenomics; Competition and Communication(Role of small molecules ,Sequence-based screening for small molecules ,Antibiotics as signal molecules).

Adaptations of microbes to environmental conditions; Role of microbes in biogeochemical cycles-Carbon cycle-Syntropy and methanogenesis, Nitrogen cycle ,Sulphur cycle, Phosphorus cycle & Iron cycle ; Corrosion by microbes –Metal & Concrete; Desulphurization of coal.

Unit IV

Ecological aspects of animal diseases; water and food borne pathogens-environmentally transmitted pathogens, indicator microorganisms -fecal Coliforms,*E.coli*, fecal *Streptococci*, *Clostridium perfringens* & Bacteriophage

Microbial interactions with pathogenesis: Symbiosis with insects(termites, Buchnera-aphid symbiosis,

Proteobacterium-tube worm symbiosis;; symbiotic relationship between ants and fungi;Symbiotic microbes in marine invertebrates (endosymbionts in Riftia & other sulphide oxidising symbionts , bioluminescent symbionts in the oceans); Microbe plant symbiosis(Dye azotropic bacteria and plant symbiosis) Fungi –plant symbiosis;Mutualism; Commensalism-Normal microbiota of human body;Microbial endophytes.

Role of microbes in: (i) Microbial leaching of ores (ii) Recovery of Petroleum, Petroleum biodegradation(iii) Biodegradation of xenobiotics (iv) Fuel production (v) Production of microbial biomass (vi) Microbial control of pests.

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 microorganisms.
7. Isolation of Rhizobium from roots of leguminous plant.
8. Slides as per syllabus.

Suggested Books:

1. Atlas R.M. and Bartha R., 1998, Microbial Ecology: Fundamentals and Applications..4th edition, Benjamin /Cummings.
2. Barton L. L. and Northup D. E., 2011, The Microbial Habitat: An Ecological Perspective. Wiley.
3. Barton L.L. and Northup D.E., 2011, Microbial Ecology. Wiley-Blackwell.
4. 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.
5. 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.
6. Maier R.M., Pepper I.L. and Gerba C.H., 2009, Environmental Microbiology. Academic Press, Elsevier.
7. Oladale O., 2005. Microbial Diversity. Blakewell Publishing.
8. Osborn M. and Smith C., 2005, Molecular Microbial Ecology. Taylor & Francis.

PAPER –III INDUSTRIAL MICROBIOLOGY

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 acid and 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.

PAPER-IV GENOMICS AND PROTEOMICS

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.