CURRICULUM AND CREDIT FRAMEWORK

for

FOUR-YEAR UNDERGRADUATE PROGRAMME (FYUP)

in

MOLECULAR BIOLOGY & BIOTECHNOLOGY

(*As per provisions of NEP 2020*)

With Effect from Academic session 2023 - 2024

Undergraduate Board of Studies

In

Molecular Biology & Biotechnology

UNIVERSITY OF KALYANI

COURSE STRUCTURE FOR B.SC. MAJOR
IN
MOLECULAR BIOLOGY AND BIOTECHNOLOGY

SEMESTER III							
Course Code	**Course Title**	**Nature of Course**	**Credit of Course**	**Class hour/ week**	**Evaluation**		**Total**
					IA	**Sem End**	
MBBT – M-T-3	**GENETICS**	Major	4	4	15	40	55
MBBT – M-P-3			2	4		20	20
MBBT – MI-T-2	**BIOLOGY OF MICROORGANISMS** To be **OPTED** by the students from **OTHER** department	Minor	3	3	10	30	40
MBBT – MI-P-2			1	2		10	10
MBBT– MU- T-3	To be developed and offered by respective colleges. To be **OPTED** by the students from **OTHER** department	Multidisciplinary	3	3	10	35	45
AEC	XXX	Ability Enhancement	X	X	X	X	X
MBBT – SEC- T-3	**(A) BIOFERTILIZER OR (B) MOLECULAR DIAGNOSTICS**	Skill Enhancement	3	3	10	35	45
VAC-T-2	Content from common pool	Value added	4	4	10	40	50
IN	XXX	Internship	X	X	X	X	X
05	Total		20	23	55	210	265

XXX – Component is not part of course structure of current semester

COURSE STRUCTURE FOR B.SC. MAJOR
IN
MOLECULAR BIOLOGY AND BIOTECHNOLOGY

SEMESTER IV							
Course Code	**Course Title**	**Nature of Course**	**Credit of Course**	**Class hour/ week**	**Evaluation**		**Total**
					IA	**Sem End**	
MBBT – M-T-4	**GENERAL MICROBIOLOGY**	Major	4	4	15	40	55
MBBT – M-P-4			2	4		20	20
MBBT – M-T-5	**BIOPHYSICS**	Major	4	4	15	40	55
MBBT – M-P-5			2	4		20	20
MBBT – MI-T-2	**BIOLOGY OF MICROORGANISMS** To be **OPTED** by the students from **OTHER** department	Minor	3	3	10	30	40
MBBT – MI-P-2			1	2		10	10
MBBT– MU	**XXX**	Multidisciplinary	X	X	X	X	X
AEC	**MIL** (Content from common pool)	Ability Enhancement	4	4	10	40	50
SEC	**XXX**	Skill Enhancement	X	X	X	X	X
VAC	**XXX**	Value added	X	X	X	X	X
IN	**Additional for Diploma**	Internship	4	8			
04 + 01	Total		20+4	25+8	50	200	250

XXX – Component is not part of course structure of the current semester

Title of the Paper: GENETICS

Code: MBBT – M-T-3

Course Category: MAJOR (Theory)

Theory – 4 Credits

Total: 60 hrs (4hrs/week)

UNIT I (10 periods)
Introduction: Historical developments in the field of genetics. Organisms suitable for genetic experimentation and their significance. Cell Cycle: Mitosis and Meiosis: Control points in cell-cycle progression in yeast. Role of meiosis in life cycles of organisms. Mendelian genetics: Mendel's experimental design, monohybrid, di-hybrid and tri hybrid crosses, Law of segregation & Principle of independent assortment. Verification of segregates by test and back crosses, Chromosomal theory of inheritance, Allelic interactions: Concept of dominance, recessiveness, incomplete dominance, co-dominance, semi-dominance, pleiotropy, multiple allele, pseudo-allele, essential and lethal genes, penetrance and expressivity.
UNIT II (15 periods)
Non allelic interactions: Interaction producing new phenotype complementary genes, epistasis (dominant & recessive), duplicate genes and inhibitory genes. Chromosome and genomic organization: Eukaryotic nuclear genome nucleotide sequence composition –unique & repetitive DNA, satellite DNA. Centromere and telomere DNA sequences, middle repetitive sequences- VNTRs & dinucleotide repeats, repetitive transposed sequences- SINEs & LINEs, middle repetitive multiple copy genes, noncoding DNA. Genetic organization of prokaryotic and viral genome. Structure and characteristics of bacterial and eukaryotic chromosome, chromosome morphology, concept of euchromatin and heterochromatin. Packaging of DNA molecule into chromosomes, chromosome banding pattern, karyotype, giant chromosomes, one gene one polypeptide hypothesis, concept of cistron, exons, introns, genetic code, gene function.
UNIT III (15 periods)
Chromosome and gene mutations: Definition and types of mutations, causes of mutations, molecular basis, Phenotypic effects, Ames test for mutagenic agents, screening procedures for isolation of mutants, variation in chromosome number and structure - Ploidy- euploid, aneuploid, monoploid, diploid, triploid, tetraploid, polyploid, amphidiploid, nullisomy, monosomy, trisomy, etc., deletion, duplication, inversion and translocation (reciprocal and Robertsonian), Associated diseases and Evolutionary Significance; Cytogenetics of human disorder - Turner syndrome, Klinefelter syndrome, Down syndrome etc., Human karyotype, Procedures to detect chromosomal aberrations in human fetuses.
UNIT IV (10 periods)
Genetic linkage, crossing over and chromosome mapping: Linkage and Recombination of genes in a chromosome crossing over, Cytological basis of crossing over, Molecular mechanism of crossing over, Crossing over at four strand stage, Multiple crossing overs Genetic mapping.
UNIT V (10 periods)
Analysis of single gene inheritance in pedigrees – symbols used in pedigree charts, autosomal, X-linked, mitochondrial, and pseudoautosomal inheritance patterns, Hemophilia, Colour blindness, Fragile-X- syndrome, LHON; mosaicism, unstable repeat

expansions.
Sex determination and sex linkage: Mechanisms of sex determination, Environmental factors, Genic balance theory, Barr bodies, Dosage compensation – hyperactivation, hypoactivation, and inactivation of X-linked genes, sex influenced traits.

Title of the Paper: GENETICS
Code: MBBT – M-P-3
Course Category: MAJOR (Practical)
Practical – 2 Credits

Total: 60 hrs (4hrs/week)

1. Permanent and temporary mount of mitosis.
2. Permanent and temporary mount of meiosis.
3. Mendelian deviations in dihybrid crosses
4. Demonstration of - Barr Body –
5. Translocation study in Rheo.
6. Karyotyping with the help of photographs
7. Pedigree charts of some common characters like blood group, color blindness and PTC tasting.
8. Study of polyploidy in onion root tip by colchicine treatment.

SUGGESTED READING

1. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics.V Edition. John Wiley and Sons
2. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics.IX Edition. Benjamin Cummings.
3. Russell, P. J. (2009). Genetics- A Molecular Approach.III Edition. Benjamin Cummings.
4. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. IX Edition. Introduction to Genetic Analysis, W. H. Freeman & Co
5. Nussbaum R.L., McInnes R.R., Willard H.F. (2007). Thompson and Thompson – Genetics in Medicine. VIII Edition, Saunders – Elsevier
6. Elrod S L & Stansfield W D. Schaum's Outline Genetics. McGraw Hill

Title of the Paper: GENERAL MICROBIOLOGY

Code: MBBT – M-T-4

Course Category: MAJOR (Theory)

Theory – 4 Credits

Total: 60 hrs (4hrs/week)

UNIT I (10 periods)
1.1 Fundamentals, History and Evolution of Microbiology. Classification of microorganisms: Microbial taxonomy, criteria used including molecular approaches, Microbial phylogeny and current classification of bacteria. 1.2 Microbial Diversity: Distribution and characterization Prokaryotic and Eukaryotic cells, Morphology and cell structure of major groups of microorganisms eg. Bacteria, Algae, Fungi, Protozoa and Unique features of viruses.
UNIT II (10 periods)
2.1 Cultivation and Maintenance of microorganisms: Nutritional categories of micro-organisms, methods of isolation, Purification and preservation.
UNIT III (20 periods)
3.1 Microbial growth: Growth curve, Generation time, synchronous batch and continuous culture, measurement of growth and factors affecting growth of bacteria. 3.2 Microbial Metabolism: Metabolic pathways, amphi-catabolic and biosynthetic pathways Bacterial Reproduction: Transformation, Transduction and Conjugation. Endospores and sporulation in bacteria.
UNIT IV (20 periods)
4.1 Control of Microorganisms: By physical, chemical and chemotherapeutic Agents. Water Microbiology: Bacterial pollutants of water, coliforms and non-coliforms. Sewage composition and its disposal. 4.2 Food Microbiology: Important microorganism in food Microbiology: Moulds, Yeasts, bacteria. Major food born infections and intoxications, Preservation of various types of foods. Fermented Foods.

Title of the Paper: GENERAL MICROBIOLOGY

Code: MBBT – M-P-4

Course Category: MAJOR (Practical)

Practical – 2 Credits

Total: 60 hrs (4hrs/week)

1. Isolation of bacteria & their biochemical characterization.
2. Staining methods: simple staining, Gram staining, spore staining, negative staining, hanging drop.
3. Preparation of media & sterilization methods, Methods of Isolation of bacteria from different sources.
4. Determination of bacterial cell size by micrometry.
5. Enumeration of microorganism - total & viable count.

SUGGESTED READING

1.Alexopoulos CJ, Mims CW, and Blackwell M. (1996). Introductory Mycology. 4 th edition. Johnand Sons, Inc.

2. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.

3. Kumar HD. (1990). Introductory Phycology.2nd edition.Affiliated East Western Press.

4. Madigan MT, Martinko JM and Parker J. (2009). Brock Biology of Microorganisms. 12th edition. Pearson/Benjamin Cummings.

5. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology.5th edition. McGraw Hill Book Company.

6. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.

7. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9 th edition. Pearson Education.

8. Willey JM, Sherwood LM, and Woolverton CJ.(2008). Prescott, Harley and Klein's Microbiology.7th edition.McGraw Hill Higher Education.

Title of the Paper: BIOPHYSICS

Code: MBBT – M-T-5

Course Category: MAJOR (Theory)

Theory – 4 Credits

Total: 60 hrs (4hrs/week)

UNIT I (10 periods)
1.1 Atomic structure and bonding: Intermolecular attractions, hydrogen bonding, vanderwaals force, hydrophobic and hydrophilic bond, polar bond, properties of water. 1.2 Thermodynamics, reaction kinetics and energy transduction: Isolated, closed, and open systems; First and second laws of thermodynamics and their biological significance; Activation energy and transition-state theory; Different orders of chemical reactions, free energy, and chemical reaction. high energy phosphate compounds (ATP, creatine phosphate, thioesters). 1.3 General Biophysics and biochemistry– Acid, base, salt, buffers, pH, pK, Henderson, Hasselbalch equation, principle of measurement of pH.
UNIT II (20 periods)
2.1 Isotopes and radioactivity: Radioactivity, decay law, Radioactive labeling, Detection and measurement of radioactive dose by GM counter, scintillation counter, autoradiography. 2.2 Hydrodynamic properties: Surface tension, diffusion, osmosis, sedimentation at molecular level. Factors affecting them. 2.3 Centrifugation – Basic Principle of Centrifugation, Instrumentation of Ultracentrifuge (Preparative, Analytical), Factors affecting Sedimentation velocity, Standard Sedimentation Coefficient, Centrifugation of associating systems, Rate-Zonal centrifugation, sedimentation equilibrium Centrifugation.
UNIT III (20 periods)
3.1 X-Ray Crystallography – X-ray diffraction, Bragg equation, Reciprocal lattice, Miller indices & Unit cell, Concept of different crystal structure, determination of crystal structure [concept of rotating crystal method, powder method]. 3.2 Absorption Spectroscopy – Properties of light, molecular mechanism of the absorption of light by molecules, Beer-Lambert law, Factors affecting the absorption properties of a Chromophore. Infrared spectroscopy, Atomic absorption and emission spectroscopy, dynamic light scattering.
UNIT IV (10 periods)
4.1 Spectroscopy: Raman Spectroscopy – Raman Effect, Quantum mechanical reason of Raman effect, NMR Spectroscopy – Basic principle of NMR spectroscopy, Experimental technique & instrumentation, Chemical shift, Hyperfine splitting, Relaxation process.

Title of the Paper: BIOPHYSICS

Code: MBBT – M-P-5

Course Category: MAJOR (Practical)

Practical – 2 Credits

Total: 60 hrs (4hrs/week)

1. Preparation of buffers: Citrate, Tris-HCl, Phosphate buffer.
2. Use of pH meter
3. Titration of amino acid (Glycine) for determination of pKa
4. ECG pattern study.
5. Column chromatography.
6. Interpretation and measurement of X-ray diffraction pattern.
7. Verify Lambert-Beer's law by Spectrophotometer.
8. Spectrophotometric determination of unknown concentration of biomolecules (Protein/ carbohydrate/ DNA/ RNA)
9. Study the activity of any enzyme under optimum conditions
10. Paper chromatographic separation technique: Separation of amino acids and pigments after extractionfrom plants.
11. Thin layer (TLC) & Column chromatographic technique.

SUGGESTED READING

1. Physical Biochemistry. David Friefelder.2-nd edition, W.H.Freeman and Company.

2. Physical Biochemistry, Upadhaya, Upadhaya, Nath, Himalaya Publishers.

3. Nelson, D.L. Cox M.M. Lehninger Principles of Biochemistry, 6-th edition.

Title of the Paper: BIOFERTILIZER

Code: MBBT – SEC- T-3 A

Course Category: SEC (Theory Only)

Theory – 3 Credits

Total: 45 hrs (3hrs/week)

UNIT I (15 periods)
General account about the microbes used as biofertilizer – Rhizobium – isolation, identification, mass multiplication, carrier-based inoculants, Actinorrhizal symbiosis. Azospirillum: isolation and mass multiplication – carrier-based inoculant, associative effect of different microorganisms. Azotobacter: classification, characteristics – crop response to Azotobacter inoculum, maintenance, and mass multiplication. Cyanobacteria (blue green algae), Azolla and Anabaena azollae association, nitrogen fixation, factors affecting growth, blue green algae and Azollain rice cultivation.
UNIT II (15 periods)
Mycorrhizal association- types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth, and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants. Organic farming – Green manuring and organic fertilizers, Recycling of biodegradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application.
UNIT III (15 periods)
Application based capacity building through educational tours or virtual/ hands-on demonstration of principles and concepts with respect to the following: 1. Preparation and sterilization of Media- Jensen's medium, Pikovskaya's agar, Aleksandrow agar. 2. Isolation of Nitrogen-fixing, Phosphate & Potassium solubilizing bacteria from soil. 3. Preparation of Biofertilizer using Plant Growth Promoting Bacteria and Vermicompost. 4. Visit to an Organic Farm or Biogas Plant.

SUGGESTED READING

1. Dubey, R.C., 2005 A Text book of Biotechnology S.Chand& Co, New Delhi.
2. Kumaresan, V. 2005, Biotechnology, Saras Publications, New Delhi.
3. John JothiPrakash, E. 2004. Outlines of Plant Biotechnology.Emkay _Publication, New Delhi.
4. Sathe, T.V. 2004 Vermiculture and Organic Farming. Daya publishers.
5. Subha Rao, N.S. 2000, Soil Microbiology, Oxford & IBH Publishers, New _Delhi.
6. Vayas,S.C, Vayas, S. and Modi, H.A. 1998 Bio-fertilizers and organic _Farming Akta Prakashan, Nadiad

Title of the Paper: MOLECULAR DIAGNOSTICS

Code: MBBT – SEC- T-3 B

Course Category: SEC (Theory Only)

Theory – 3 Credits

Total: 45 hrs (3hrs/week)

UNIT I (15 periods)

Enzyme Immunoassays:

Comparison of enzymes available for enzyme immunoassays, conjugation of enzymes. Solid phases used in enzyme immunoassays. Homogeneous and heterogeneous enzyme immunoassays. Enzyme immunoassays after immuno blotting. Enzyme immune-histochemical techniques. Use of polyclonal or monoclonal antibodies in enzymes immuno assays. Applications of enzyme immunoassays in diagnostic microbiology

Molecular methods in clinical microbiology:

Applications of PCR, RFLP, Nuclear hybridization methods, Single nucleotide polymorphism and plasmid finger printing in clinical microbiology

UNIT II (15 periods)

Laboratory tests in chemotherapy:

Susceptibility tests: Micro-dilution and macro-dilution broth procedures. Susceptibility tests: Diffusion test procedures. Susceptibility tests: Tests for bactericidal activity. Automated procedures for antimicrobial susceptibility tests. Automation in microbial diagnosis, rapid diagnostic approach including technical purification and standardization of antigen and specific antibodies. Concepts, and methods in idiotypes. Anti-idiotypes and molecular mimicry and receptors. Epitope design and applications. Immunodiagnostic tests. Immuno florescence. Radioimmunoassay.

UNIT III (15 periods)

Virtual demonstration/ study tour to depict the application of molecular diagnostic techniques in the identification and diagnosis of the following genetic disorders, and microbial diseases:

1. *Bacterial & viral diagnostics*-
   PCR diagnosis of *Mycobacterium tuberculosis*.
   HIV and SARS nCOV-2 detection by RT-qPCR.
2. *Molecular diagnostics of genetic diseases*-
   Genetic testing in Sickle cell anemia, Beta thalassemia, Cystic fibrosis.
3. *Cancer diagnostics*-
   Checking of BRCA gene polymorphism for susceptibility to breast cancer.
4. *Foetal diagnostics*-
   Prenatal molecular diagnosis by Chorionic Villus Sampling and Amniocentesis
5. *Cytogenetic diagnostics*-
   Karyotype by Q-banding and G-banding - Molecular diagnosis of Klinefelter, Down and Turner syndromes; Molecular cytogenetics: FISH - Types and clinical applications.

SUGGESTED READING

1. Practical Biochemistry, Principles and Techniques, Keith Wilson and John Walker.
2. Advanced Instrumentation, Data Interpretation, and Control of Biotechnological Processes, J.F. Van Impe,Kluwer Academic.
3. Ananthanarayan R and Paniker CKJ. (2005). Textbook of Microbiology.7th edition (edited by Paniker CKJ).University Press Publication.
4. Brooks GF, Carroll KC, Butel JS and Morse SA. (2007). Jawetz, Melnick and Adelberg's Medical Microbiology.24th edition.McGraw Hill Publication.
5. Goering R, Dockrell H, Zuckerman M and Wakelin D. (2007). Mims' Medical Microbiology.4th edition.Elsevier.
6. Joklik WK, Willett HP and Amos DB (1995). Zinsser Microbiology.19th edition.Appleton-Centuary- Crofts publication.
7. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology.7th edition.McGraw Hill Higher Education.
8. Microscopic Techniques in Biotechnology, Michael Hoppert
9. Strachan, T. and A.P. Read. 2004. Human Molecular Genetics. 3rd Edition. Garland Science, UK.
10. A Practical Guide to Clinical Virology. 2nd Ed. L.R. Haaheim., J.R. Pattison. R.J.Whitley. John Wiley &Sons, 1994.
11. Biomedical Methods Hand Book– John M. Walkser, Ralph Raplay. Humana Press, 2005.

To be opted by OTHER DEPARTMENT students either during Sem III OR Sem IV

Title of the Paper: BIOLOGY OF MICROORGANISMS

Code: MBBT – MI-T-2

Course Category: MINOR (Theory)

Theory - 3 Credits

Total: 45 hrs (3hrs/week)

UNIT I (10 periods): History of microbiology and an overview of bacterial structure
1.1 The Discovery of Microorganisms and contributions of Louis Pasteur, and Edward Jenner, Leeuwenhoek, the Conflict over spontaneous generation, Koch's postulates, the Scope and relevance of Microbiology 1.2 An overview of procaryotic cell structure; procaryotic cell membranes; the cytoplasmic matrix (inclusion bodies), ribosomes, the nucleoid, the procaryotic cell wall (gram positive & gram negative), the mechanism of gram staining; Components external to the cell wall (capsules, slime layers, and s-layers; pili and fimbriae), flagella and motility (flagellar ultrastructure, mechanism of flagellar movement, chemotaxis); the bacterial endospore
UNIT II (15 periods): Microbial nutrition, growth, and control
2.1 Nutrient requirement for bacterial growth (macro- and micronutrients, purines, pyrimidines, amino acids, vitamins), iron Uptake and Siderophores, Nutritional Types of Microorganisms; types of media (synthetic, complex, differential media) 2.2 Isolation of Pure Cultures (The Spread Plate and Streak Plate, The Pour Plate); the Growth Curve, the mathematics of growth Measurement of Microbial Growth (Cell Numbers, Cell Mass), The Continuous Culture of Microorganisms (Chemostat, Turbidostat) 2.3 The Influence of Environmental Factors on Growth (extremophiles, Halophiles), effect of pH, Temperature (Psychrophiles, Mesophiles, thermophiles, hyperthermophiles) Pressure; Quorum Sensing and Microbial Populations 2.4 The physical Methods used to control bacteria (Heat, Low Temperatures, Filtration, Radiation), The chemical Methods used to control bacteria (Phenolics, Alcohols, Halogens
UNIT III (10 periods): Virology
3.1 General Properties of Viruses, cultivation of Viruses, Viral multiplication, Attachment, entry, un-coating, replication, assembly, release, Cell transformations, Cultivation of viruses-Assay techniques 3.2 The Structure of Viruses (Virion Size, General Structural Properties, Helical Capsids) types of viral nucleic Acids, Viral Envelopes and Enzymes 3.3 Animal viruses-Virus-Host interactions - Viral infections, plant viruses, bacteriophages 3.4 Host response and antiviral agents, immune responses to viruses, interferon and other cytokines, antiviral therapy, vaccines against SARS nCOV-2 and the Covid19 pandemic
UNIT IV (10 periods): Food and Industrial Microbiology
4.1 Microbial Growth and Food Spoilage, Controlling Food Spoilage, Removal of Microorganisms (Low Temperature, High Temperature, Pasteurization) Chemical-Based Preservation, Radiation, bacteriocins 4.2 Food-Borne Diseases, Food-Borne Infection, Food-Borne Intoxications, Detection of Food-Borne Pathogens 4.3 Production of Fermented Milks (buttermilk, sour cream, and yogurt); Cheese Production; Production of Alcoholic Beverages (Wines and Champagnes, Beers and Ales, Distilled Spirits), Production of Breads, a brief concept on probiotics.

Title of the Paper: BIOLOGY OF MICROORGANISMS

Code: MBBT – MI-P-2

Course Category: MINOR (Practical)

Practical- 1 Credit

Total: 30 hrs (2hrs/week)

1. Demonstration, use and care of microbiological equipment.
2. Preparation of media, sterilization, and isolation of bacteria.
3. Simple staining of bacteria
4. Gram staining of Bacteria
5. Endospore staining.
6. Demonstration of starch hydrolysis by bacterial cultures.
7. Growth of fecal coliforms on selective media.
8. Isolation of pure culture by streak plate method.
9. Antibiotic sensitivity assay.

SUGGESTED READING

1. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7thedition, CBS Publishers and Distributors, Delhi, India.
2. Madigan MT, Martinko JM and Parker J. (2009). Brock Biology of Microorganisms. 12th edition. Pearson/Benjamin Cummings.
3. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.
4. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.
5. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9 th edition. Pearson Education.
6. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education
7. Cappucino, J. and Sherman, N. (2007) Microbiology: A laboratory manual. VII Edition. Pearson Education.
8. Black, J.G. Microbiology: Principles and exploration. John Wiley and Sons, New Jersey.