REVISED T.Y.BSc MICROBIOLOGY SYLLABUS, MUMBAI UNIVERSITY

2010 ONWARDS

WORKSHOP HELDAT

WILSON COLLEGE

29th APRIL 2010

REVISED SYLLABUS FOR T Y B Sc Microbiology

2010-11 Onwards

Students opting for 6 Units of Microbiology (Major) at T Y B Sc level will study Papers I, II, III, IV of 100 marks each and 4 practicals based on these papers of 50 marks each.

Students opting for 3 Units of Microbiology at T Y B Sc level will study Papers I & II of 100 marks each and 2 practicals based on these papers of 50 marks each.

Paper wise Units Summary

	Paper I	Paper II	Paper III	Paper IV
Title	Genetics, Bioinformatics, Molecular Biology & Virology	Medical microbiology and immunology	*Microbial Biochemistry*	*Bioprocess Technology*
Unit 1*	Classical genetics	Medical Microbiology	Solute transport Bioenergetics & Bioluminescence	Upstream Processing
Unit 2*	DNA replication, Mutation & Repair	Medical Microbiology Chemotherapy, Quality Assurance in Diagnostics	Methods & Carbohydrate metabolism	Downstream Processing
Unit 3*	Recombinant DNA technology	General Immunology	Metabolism of Lipid, Protein, Nucleic acid & Aromatic compounds	Traditional Industrial Fermentations
Unit 4*	Virology	Immune system in Health & Disease	Metabolic regulation Photosynthesis & Inorganic metabolism	Advances in Bioprocess Technology

* Note: Each Unit is of 30 lectures

Paper I- Genetics, Bioinformatics, Molecular Biology & Virology (120 lectures)

Unit	Topic	Lectures
I	Classical genetics	30
II	DNA replication, Mutation & Repair	30
II	Recombinant DNA technology	30
IV	Virology	30

I. Unit 1: - Classical Genetics (30)

1. Branches of Genetics [1]
   A. Transmission genetics
   B. Molecular genetics
   C. Population genetics
   D. Quantitative genetics.
2. Model Organisms [1]
   A. Characteristics of a model organism
   B. Examples of model organisms used in study
   C. Examples of studies undertaken using prokaryotic and eukaryotic model organisms.
3. Genetic Exchange [18]
   A. Genetic analysis of bacteria
   B. Transformation
      i. Introduction and History
      ii. Types of transformation in prokaryotes--Natural transformation in *Streptococcus pneumoniae, Haemophilus influenzae,* and *Bacillus subtilis*
      iii. Mapping of bacterial genes using transformation.
      iv. Problems based on transformation.
   C. Conjugation
      i. Discovery of conjugation in bacteria
      ii. Properties of F plasmid/Sex factor
      iii. The conjugation machinery
      iv. Hfr strains, their formation and mechanism of conjugation
      v. F' factor, origin and behavior of F' strains, Sexduction.
      vi. Mapping of bacterial genes using conjugation (Wolman and Jacob experiment).
      vii. Problems based on conjugation
   D. Transduction
      i. Introduction and discovery
      ii. Generalised transduction

iii. Use of Generalised transduction for mapping genes
iv. Specialised transduction
v. Problems based on transduction

4. Plasmids [4]
   A. Physical nature
   B. Detection and isolation of plasmids
   C. Plasmid incompatibility and Plasmid curing
   D. Cell to cell transfer of plasmids
   E. Types of plasmids
      i. Resistance Plasmids,
      ii. Plasmids encoding Toxins and other Virulence Characteristics
      iii. col factor
      iv. Degradative plasmids
5. Transposable Elements in Prokaryotes [4]
   A. Insertion sequences
   B. Transposons
      i. Types
      ii. Structure and properties
      iii. Mechanism of transposition
      iv. Transposon mutagenesis
   C. Integrons

6. Recombination in bacteria [2]
   A. General/Homologous recombination
      i. Molecular mechanism
      ii. Holliday model of recombination
   B. Site –specific recombination

II. Unit 2: DNA replication, Mutation and Repair (30)

1. Replication of DNA [12]
   A. Historical perspective— conservative, dispersive, semi-conservative, bidirectional, semi-discontinuous and θ mode of replication
   B. Prokaryotic DNA replication – Details of molecular mechanism involved in Initiation, Elongation and Termination
   C. Enzymes and proteins associated with DNA replication- primase, helicase, topoisomerase, SSB, DNA polymerases, ligases, Ter and Tus proteins.
   D. Eukaryotic DNA replication-- Molecular details of DNA synthesis, replicating the ends of the chromosomes, assembly of new DNA into nucleosomes
   E. Rolling circle mode of replication

2. Mutation [13]
   Terminology: alleles, homozygous, heterozygous, genotype, phenotype, Somatic mutation, Germline mutation, Gene mutation, Chromosome mutation, phenotypic lag, hotspots and mutator genes
   Fluctuation test.
   Types of mutations: Point mutation, reverse mutation, suppressor mutation, frameshift mutation, conditional lethal mutation, base pair substitution, transition, transversion, missense mutation, nonsense mutation, silent mutation, neutral mutation, pleiotropic mutations.
   Causes of mutation:

i. Natural/spontaneous mutation--replication error, depurination, deamination.
ii. Induced mutation: principle and mechanism with illustrative diagrams for
    a. Chemical mutagens- base analogues, nitrous acid, hydroxyl amine, intercalating agents and alkylating agents
    b. Physical mutagen
    c. Biological mutagen

Ames test.
Detection of mutants.
Complementation test.

3. DNA Repair [5]
   A. Mismatch repair,
   B. Light repair
   C. Repair of alkylation damage
   D. Base excision repair
   E. Nucleotide excision repair
   F. SOS repair
   G. Double strand break repair
   H. Post replicative repair

III. Unit 3: Recombinant DNA technology (30)

1. Recombinant DNA technology [22]
   A. Basic steps in Gene Cloning.
   B. Cutting and joining DNA molecules--Restriction and modification systems, restriction endonucleases, DNA ligases, Adaptors and linkers.
   C. Vectors
      i. Plasmids as cloning vectors. The plasmid vectors, pBR322 vector
      ii. Cloning genes into pBR322
      iii. Phage as cloning vectors, cloning genes into phage vector
      iv. Cosmids
      v. Shuttle vectors
      vi. Expression vectors
      vii. YAC
   D. PCR- basic PCR and different types of PCR (Reverse transcriptase PCR, Real time quantitative PCR and Long accurate PCR)
   E. Methods of transformation.
   F. Construction of genomic and cDNA libraries.
   G. Basic techniques
      i. Southern, Northern and Western blotting.
      ii. Preparation of radioactive and non-radioactive DNA probes
      iii. Autoradiography.
   H. Screening and selection methods for identification and isolation of recombinant cells.
   I. Applications of recombinant DNA technology.

2. Bioinformatics [8]
   A. Introduction
      i. Definition, aims, tasks and applications of Bioinformatics.
      ii. Database, tools and their uses
          a. Importance, Types and classification of databases

b. Nucleic acid sequence databases- EMBL, DDBJ, GenBank, GSDB, Ensembl and specialized Genomic resources.
c. Protein sequence databases-PIR, SWISS-PROT, TrEMBL NRL-3D.Protein structure databases-SCOP, CATH, PROSITE, PRINTS and BLOCKS. KEGG.

B. Brief introduction to Transcriptome, Metabolomics, Pharmacogenomics, Phylogenetic analysis, Phylogenetic tree, Annotation, QSAR (quantitative structure activity relationship), Docking algorithms
C. Sequence alignment-- global v/s local alignment, FASTA, BLAST.
D. Genomics- structural, functional and comparative genomics.
E. Proteomics- structural and functional proteomics.

IV. Unit 4: Virology (30)

1. Viral architecture- [4]
   A. Capsid, viral genome and envelope
   B. Structure of TMV, T4, Influenza virus, HIV.
2. Viral classification [1]
3. The viral replication cycle- attachment, penetration, uncoating, types of viral geome and their replication, assembly, maturation and release. Life cycle of T4 phage, TMV, Influenza Virus and HIV in detail [8]
4. Cultivation of viruses- [3]
   cell culture techniques, embryonated egg, laboratory animals
5. Visualization and enumeration of virus particles [7]
   A. Measurement of infectious units
      i. Plaque assay
      ii. Fluorescent focus assay
      iii. Infectious center assay
      iv. Transformation assay
      v. Endpoint dilution assay.
   B. Measurement of virus particles and their components
      i. Electron microscopy
      ii. Atomic force microscopy
      iii. Haemagglutination
      iv. Measurement of viral enzyme activity.
   C. Fate of the cells following virus infection
6. Regulation of lytic and lysogenic pathway of lambda phage [3]
7. Role of viruses in cancer [2]
8. Prions and viroids [2]

Text books

1. Peter J. Russell (2006), “Genetics-A molecular approach”, 2nd /3rd ed.
2. Benjamin A. Pierce (2008), “Genetics a conceptual approach”, 3rd ed., W. H. Freeman and company.
3. R. H. Tamarin, (2004), “Principles of genetics”, Tata McGraw Hill.
4. D,.Nelson and M.Cox, (2005), “Lehninger’s Principles of biochemistry”, 4th ed., Macmillan worth Publishers.

5. M.Madigan, J.Martinko, J.Parkar, (2009), "Brock Biology of microorganisms", 12th ed., Pearson Education International.
6. Fairbanks and Anderson, (1999), "Genetics", Wadsworth Publishing Company.
7. Prescott, Harley and Klein, "Microbiology",. 7th edition Mc Graw Hill international edition.
8. Edward Wagner and Martinez Hewlett, (2005) "Basic Virology", 2nd edition, Blackwell Publishing
9. Teri Shors,.(2009) , "Understanding viruses", Jones and Bartlett publishers.
10. S.Ignacimuthu, (2005), "Basic Bioinformatics", Narosa publishing house.
11. Robert Weaver, (), "Molecular biology", , 3rd edn. Mc Graw Hill international edition.
12. Nancy Trun and Janine Trempy, (2004), "Fundamental bacterial genetics", Blackwell Publishing
13. Primrose and Twyman, "Principles of gene manipulation and genomics", 6th/7th ed, Blackwell Publishing
14. Arthur Lesk, (2009), "Introduction to Bioinformatics", 3rd Edition, Oxford University Press

Reference books:

1. Flint, Enquist, Racanillo and Skalka, "Principles of virology", 2nd edn. ASM press.
2. T. K. Attwood & D. J. Parry-Smith, (2003), "Introduction to bioinformatics", Pearson education
3. Benjamin Lewin, (), "Genes IX", , Jones and Bartlett publishers.
4. JD Watson, "Molecular biology of the gene", , 5th edn.
5. Snustad, Simmons, "Principles of genetics", 3rd edn. John Wiley & sons, Inc.

PRACTICALS BASED ON PAPER 1

1. Enrichment of coliphages, phage assay (pilot & proper).
2. UV survival curve – determination of exposure time leading to 90% reduction
3. Isolation of mutants using UV mutagenesis
4. Replica plate technique for selection & characterization of mutants – auxotroph & antibiotic resistant
5. Isolation and detection of plasmid DNA.
6. Preparation of competent cells and transformation
7. Restriction analysis.
8. Isolation of genomic DNA of *E. coli*
9. PCR (Demo)
10. Western Blot.(Demo)
11. Genetics problems.
12. Bioinformatics practical
    A. Off Line Practical
        i. Familiarity with your computer
        ii. Installation of representative software for off line use – SPDBV and Bioedit
        iii. Visualizing and manipulating Protein structure database files using SPDBV
        iv. Sequence Alignment, dot plot, phylogenetic tree building exercise using Bioedit
    B. On Line Practical
        i. Visiting NCBI and EMBL websites & list services available, software tools available and databases maintained
        ii. Visiting & exploring various databases mentioned in syllabus and
            a. Give comparative account

b. Using BLAST and FASTA for sequence analysis
c. Fish out homologs for given specific sequences (by teacher – decide sequence of some relevance to their syllabus and related to some biological problem e.g. evolution of a specific protein in bacteria, predicting function of unknown protein from a new organism based on its homology – list can be really long and should be generated with the help of students while teaching topics in genetics, biochemistry, bioinformatics through out the year – illustrating power of informatics tools in biology)
d. Understand every item mentioned in the report generated, its significance and use in interpretation of results as well as limitations of the results.

13. Animal cell culture (demo)

PAPER II: MEDICAL MICROBIOLOGY AND IMMUNOLOGY
(120 Lectures)

Unit	Brief Topic Description	No of Lectures
1	Medical Microbiology	30
2	Medical Microbiology (Continued), Chemotherapy, Quality Assurance in Diagnostics	30
3	General Immunology	30
4	Immune system in Health & Disease	30
	Total	120

I. UNIT1: MEDICAL MICROBIOLOGY (30)

- All infections are to be covered with respect to all details with emphasis on Etiology, Transmission, Pathogenesis, Clinical Manifestations, Lab Diagnosis, Prophylaxis, and Treatment.

1. Respiratory tract Infections [11]
   A. Upper respiratory tract:
      i. Streptococcal Pharyngitis, Diphtheria
      ii. Common Cold , Oral Candidiasis , Measles- Rubeola, Rubella, Mumps , Chicken pox, Shingles
   B. Lower Respiratory tract:
      i. Tuberculosis, Influenza
      ii. Bacterial pneumonia, Whooping cough
2. Urinary Tract Infections - Pathogens & Factors Involved [3]
3. Gastro – Intestinal Infections [9]
   A. Infectious diseases
      i. Salmonella, Shigella , Vibrio
      ii. E.coli, Helicobacter pylori, Campylobacter, Rota virus, Hepatitis A , E.histolytica
   B. Food Poisoning: Staphylococcal, Botulism
4. Central Nervous System Infections [7]
      i. Tetanus, Polio, Rabies
      ii. Meningitis: viral, bacterial -Meningococcal, Pneumococcal and Haemophilus

II UNIT 2: MEDICAL MICROBIOLOGY, CHEMOTHERAPY, QUALITY ASSURANCE (30)

1. Medical Microbiology [15]
   - All infections are to be covered with respect to all details with emphasis on Etiology, Transmission, Pathogenesis, Clinical Manifestations, Lab Diagnosis, Prophylaxis, and Treatment

   A. Sexually transmitted Infections
      i. HIV infection, Syphilis
      ii. Gonorrhea, Herpes, Hepatitis B
   B. Skin Infections
      Pyogenic Staphylococcal, Streptococcal, Leprosy, Malaria
      Candidiasis, Dermatophytosis , Pseudomonas
   C. Emerging Infections - SARS, H1N1, Avian flu, Leptospirosis, Dengue

2. Chemotherapy [12]
   A. Basics of Chemotherapy
      i. History and Development of Chemotherapy
      ii. General Properties of antimicrobial agents
      iii. Attributes of an ideal antimicrobial agent
   B. Drug Resistance: Origin, Mechanisms and Transmission
   C. Selection & Testing
   D. Principal Groups of Antibacterial Agents and Mechanism of Action
      i. Cell Wall Inhibitors
      ii. Inhibitors of Protein Synthesis
      iii. Inhibitors of Nucleic Acid Synthesis
      iv. Cell Membrane Disruptors
      v. Antimetabolites
   E. Anti-mycobacterial, Antifungal, Antiviral - Tabulation of Examples

3. Quality Assurance in Diagnostics - Concepts of Quality Assurance in Diagnostics [3]

III UNIT 3: GENERAL IMMUNOLOGY (30)

1. Cells of the immune system- T-cells, B-cells, NK-cells [1]

2. Cytokines [2]
   A. Properties and Functions
   B. Cytokines secreted by Th1 andTh2 cells

3. Antigen Presenting Cells - Antigen presentation and processing pathways, (Cytosolic and Endocytic pathway) [2]

4. MHC complex and MHC Molecules [4]
   A. Organization of MHC genes
   B. Structure of class I and class II molecules
   C. Polymorphism and Polygenism
   D. T cell antigen receptors and MHC molecules.
   E. Tests for MHC specificity.

5. T cells [7]
   A. Receptors, structure and organization
   B. T cell development and maturation, positive and negative selection
   C. T cell activation
      TCR coupled signaling pathway
      Costimulatory signals
      Superantigen induced T cell activation.

   D. T cell differentiation
      i. Generation of effector and memory cells.
      ii. Cell death and T cell population.
      iii. Functions of peripheral αβ and γδ cells

6. B cells [5]
   Receptors----structure & organization
   B cell development and maturation
   B cell activation & differentiation
      i. Thymus dependent and independent antigens.
      ii. B cell activating signals
      iii. Role of Th cells in humoral response, formation of T-B conjugates CD40/CD40L interaction, Th cell cytokine signals.

7. Humoral response [3]
   A. Induction of Humoral response, Primary and secondary responses,
   B. Germinal centers and antigen induced B cell differentiation
   C. Outline of Organization and expression of Ig genes, gene rearrangement
   D. Affinity maturation and somatic hyper mutation, Ig diversity, class switching
   E. Generation of plasma cells and memory cells, synthesis, assembly and secretion of immunoglobulins.
   F. Evaluation of humoral response.

8. Cell mediated effector response [2]
   A. Generation and target destruction by Cytotoxic T cells.
   B. Killing mechanism of NK cells.
   C. Antibody dependent cell cytotoxicity (ADCC)
   D. Experimental assessment of CM cytotoxicity.

9. Complement system [4]
   A. Complement components and notations
   B. Complement activation (classical pathway, Alternate pathway, Lectin pathway)
   C. Biological consequences of complement activation.
   D. Regulation of complement pathways.

IV UNIT 4: IMMUNE SYSTEM IN HEALTH AND DISEASE (30)

1. Antigen- Antibody reactions [5]
   Precipitation, agglutination, passive agglutination, agglutination inhibition, Complement Fixation, Radioimmunoassays (RIA), Enzyme immunoassays (EIA), Immunofluorescence, Flow cytometry, western blot technique, immunoelectron microscopy, Toxin antitoxin assays.

2. Monoclonal antibodies - Preparation, applications, Engineered antibodies. [2]

3. Vaccines [10]
   A. Active and passive immunization
   B. Types of vaccines - Killed and attenuated vaccines, Whole organism vaccines, Purified macromolecules as vaccines, recombinant vector vaccines,DNA vaccines, anti-idiotype vaccines
   C. Use of adjuvants in vaccine
   D. New vaccine strategies
   E. Ideal vaccine
   F. Route of vaccine administration ,Vaccination schedule, Failures in vaccination.

4. Immunohematology [4]
   A. Human blood group systems, ABO, secretors and non secretors, Bombay Blood group. Rhesus system and list of other blood group systems.
   B. Haemolytic disease of new borne, Coombs test.
   C. Blood Transfusion, Major and Minor Cross matching, transfusion reactions

5. Hypersensitivity – [4]
   A. Coombs and Gells classification
   B. Type I to Type IV hypersensitivity, Mechanism and manifestation.

6. Autoimmunity [2]
   A. Definition of immune tolerance,
   B. Immune suppression and autoimmunity
   C. Spectrum of autoimmune diseases,
   D. Mechanism and treatment of autoimmune diseases.

7. Transplantation immunology [3]
   A. Immunological basis of graft rejection,
   B. Types of graft rejection, Clinical manifestation of graft rejection,
   C. General and specific immunosuppresive therapy

Text books

1. Ananthanarayan and Paniker, (2009), “Textbook of Microbiology”, 8th Edition. Universal Press
2. Cedric Mims et al, “ Medical Microbiology”, 3rd Edition Mosby
3. Prescott, Harley, Klein, “Microbiology”,. 6th Edition McGraw Hill
4. Konemann, “Diagnostic Microbiology”, 5th and 6th Edition. Lippincott
5. Teri Shors Jones “Understanding Viruses” Bartlett Publishers
6. Richard A. Goldsby, Janis Kuby, “Immunology”, , 6th and 7th Edition. W. H. Freeman and company.
7. Fahim Halim Khan, “The elements of Immunology”,. Pearson Education.

8. Pathak, S., Palan U, "Immunology Essential and Fundamental" ,2nd Edition. Capital Publishing company
9. Ian R. Tizard, "Immunology, An Introduction", 4th - Edition, Saunders college publishing

Practical Syllabus Based on Paper II

1. Schematic /diagrammatic representation of each system as per the theory syllabus (Respiratory, Urinary, Gastro-intestinal, Central Nervous Systems, Skin)
2. "Diagnostic Cycle" of any one infection of each of the above systems (viz., in upper respiratory tract: Pharyngitis)
3. Samples of various forms/procedures used for diagnostic tests e.g. Request forms, QC slips, for samples, reagents, stains, media, equipment validation, Test-reports, (Results, Panic report, alert report) to be drawn or attached in the journal.
4. Tabulation of:
    A. Types of samples, containers, specimens, with reference to the symptoms/infections.
    B. Transport media with reference to samples/suspected pathogen.
    C. Collection and Processing of samples in various infections.
    D. Primary isolation of suspected pathogens in different infections with reference to pathological samples.
    E. Rapid tests for identification of pathogens e.g. oxidase, catalase, stainings (Acid fast, Metachromatic granules, Capsule), Germ tube formation.
    F. Minimum biochemical media for identification of the pathogens listed in the syllabus i.e. *S. aureus, S. pyogenes, Corynebacterium diphtheriae, E. coli, Klebsiella spp., Salmonella spp., Shigella spp., Vibrio spp., Proteus spp., Pseudomonas spp*.
    G. List of samples to be used with the above:
        i. **URT**: Nasal swab, pus,
        ii. **GIT**: Faeces, Rectal swab,
        iii. **UTI**: Urine,
        iv. **Bacteraemia**: Blood,
        v. **CNS**: CSF.
5. Case study and problem solving for identification of the pathogen and antibiotic sensitivity with reference to each of the infections (Include approach writing, suspected organisms, requirements for the identification tests and their justification rapid tests, AST reports.)
6. Perform quality control tests of media, reagents, strains and equipment used in the syllabus.
7. Kirby-Bauer method and Stokes method for AST.
8. Synergistic activity of antibiotics.
9. E test.(Demonstration)
10. Agar cup method for determination of antibiotic levels in body fluids (serum)
11. Detection of β-lactamase producer by Acidometric/Iodometric method
12. Differential Blood Count, Blood Grouping, Direct & Reverse Typing
13. Determination of Isoagglutinin titre
14. Coombs test – direct & indirect method
15. Compatibility test – cross matching.
16. Preparation of Typhoid vaccine and sterility checking

17. Antigen – Antibody Reactions: Agglutination – Widal (Demonstration); VDRL Qualitative and Quantitative (Demonstration); Immuno diffusion – Single- Oudin's; Double – Ouchterlony; SRID
18. Separation of lymphocytes and staining (Demonstration)
19. Pregnancy test – ELISA (Demonstration)
20. Rheumatoid arthritis test (Demonstration)

Paper III – Microbial Biochemistry
120 Lecturers

Unit	Topic	Lectures
I	A. Solute transport B. Bioenergetics	30
II	A) Methods for studying metabolism B) Carbohydrate metabolism	30
III	Metabolism of Lipid, Protein Nucleic acid & Aromatic compounds	30
IV	A. Metabolic regulation B. Photosynthesis C. Inorganic metabolism	30
	Total	120

I. Unit 1: Solute Transport, Bioenergetics& Bioluminescence (30)

1. Solute transport: [15]
   - A. Methods of studying solute transport
   - B. Role of membrane in solute transport
   - C. Mechanism for uptake of solutes
     - i. Passive diffusion
     - ii. Facilitated diffusion
     - iii. Active transport
       - a. Primary active transport - Histidine uptake model (Shock sensitive system), Maltose uptake
       - b. Secondary active transport- Uniport, Antiport, Symport
       - c. Active transport linked to phosphate bond energy
     - iv. Group translocation
     - v. Other examples of solute transport
       - a. Iron – transport : A special problem
       - b. Transport through outer membrane (Porin and special transport protein)
       - c. Assembly of proteins in to membranes and protein export

2. Bioenergetics [13]
   - A. Electron transport chain: components, complexes and functions
     - i. Mitochondrial ETC
     - ii. Prokaryotic ETC
       - a. Organotroph – E. Coli
       - b. Lithotroph – Nitrosomonas& Nitrobater (Only schematic)

B. Oxidative phosphorylation: by Chemiosmotic coupling hypothesis
C. Structure and mechanism of ATP synthase
    i. Structure of
        a. bacterial ATP synthase
        b. Mitochodrial ATP synthase
    ii. Mechanism – Rotational catalysis

D. Other modes of generation of electrochemical energy
    i. Oxalate formate exchange
    ii. Decarboxylases dependent ion transport
    iii. End product efflux
    iv. iv. ATP hydrolysis
E. Calculation of energetics of glycolysis, TCA and Beta oxidation of fatty acid (palmitic acid) – balance sheet to be given with efficiency calculation
F. Bacteriorhodopsin: Photo cycle and significance

3. Bioluminescence - Introduction, ETC, Significance / Application [2]

Unit II – Methods & Carbohydrate Metabolism (30)

1. Methods of studying metabolism [2]
    A. Use of biochemical mutants, Isotopic labeling, (Including radiorespirometry with reference to EMP&ED), sequential induction technique
    B. Modern methods based on biochemical genetics, molecular biological and computational techniques, concept of metabolome and its uses in the study of metabolism

2. Metabolism of Carbohydrates [28]
    A. Catabolism
        i. Breakdown of polysaccharides – glycogen, starch, cellulose
        ii. Breakdown of oligosaccharides – lactose, maltose, sucrose
        iii. Utilization of monosaccharides – fructose, galactose, mannose
        iv. Major pathways :
            a. Glycolysis (EMP)
            b. HMP Shunt
            c. ED pathway
            d. Phosphoketolase pathway (pentose & hexose phosphoketolase), Bifidobacterium pathway
            e. Other modes of fermentations in microorganisms: alcohol, mixed acid, butanediol, butyric acid, butanol-acetone, propionic acid (randomizing & non-randomizing pathway)
            f. Citric acid cycle, anaplerotic reactions, glyoxylate bypass, Incomplete TCA in anaerobic bacteria
            g. Amphibolic pathways: role of EMP and TCA cycle
    B. Anabolism
        i. Gluconeogenesis
        ii. Biosynthesis of glycogen
        iii. Biosynthesis of Peptidoglycan and Lipopolysaccharide

III Unit 3: Lipid, Proteins, Nucleic Acids & Aromatic Compound Metabolism (30)

1. Lipid metabolism [9]
   A. Catabolism
      i. Oxidation of saturated fatty acid-β oxidation pathway
      ii. Oxidation of propionic acid
      iii. Oxidation of saturated aliphatic hydrocarbon (n-alkane)-Omega oxidation pathway- Pathway in *Corynebacterium* and yeast, Pathway in *Pseudomonas*
      iv. Degradation of poly beta Hydroxyl butyrate

   B. Anabolism
      i. Biosynthesis of straight chain even carbon saturated fatty acid (palmitic acid)
      ii. Biosynthesis of PHB

2. Protein metabolism [10]
   A. Catabolism
      i. Enzymatic degradation of proteins
      ii. Metabolic fate of amino acids (schematic only)
      iii. Metabolism of single amino acids –Deamination, decarboxylation, and transamination
      iv. Fermentation of single amino acids
      v. Glutamic acid, Alanine by Clostridium propionicum
      vi. Fermentation of pair of amino acids (Stickland reaction)

   B. Anabolism
      i. Schematic representation of amino acid families
      ii. Synthesis of amino acids of Serine family- Examples - serine, cysteine, glycine

3. Nucleic acid metabolism [8]
   A. Catabolism
      i. Degradation of purine and pyrimidine nucleotides up to uric acid formation
      ii. Recycling of purines and pyrimidines nucleotides by salvage pathway-

   B. Anabolism - Synthesis of ribonucleotides and deoxyribonucleotides

4. Metabolism of aromatic compounds [3]
   A. Schematic representation for conversion of various aromatic compounds to catechol and protocatechuic acid
   B. Catabolism of catechol and protocatechuic acid by ortho and Meta cleavage

IV Unit 4: Metabolic Regulation (30)

1. Metabolic regulation [15]
   A. Cellular control mechanism acting at various levels of metabolism
   B. Allosteric proteins – Role as enzymes and regulatory proteins
   C. RNA's as regulatory molecules
   D. Regulation of gene expression
      i. Regulation in bacteria - Operon model – criteria for negative / positive types and inducible / repressible types
      ii. Regulation of enzyme synthesis (Enzyme induction/repression)

Mechanism of control of transcription

a. By DNA- Binding proteins
   - ⇒ Lac operon (Negative control of enzyme induction)
   - ⇒ Ara operon (Positive control of enzyme induction)
   - ⇒ Catabolite repression

b. Enzyme Repression in Branched Biosynthetic Pathways

c. By Attenuation
   - ⇒ Trp operon (End-Product Repression)

d. By Multiple Sigma Factors

E. Regulation of enzyme activity (Enzyme inhibition/activation)
   i. Mechanism of End-Product Inhibition
      a. Patterns of regulation-- End-Product Inhibition in branched pathways, Isofunctional enzymes, concerted feedback Inhibition, sequential feedback inhibition, Cumulative Feedback Inhibition, Combined activation and inhibition
      b. Covalent modification of regulatory of enzymes - Glutamate synthetase system of *E.coli*
      c. Regulation by proteolytic cleavage

F. Regulation of EMP, TCA and ortho cleavage pathway of aromatic compounds

2. Prokaryotic photosynthesis [7]
   A. The phototrophic prokaryotes
      i. Oxygenic phototrophs
      ii. Anoxygenic phototrophs
   B. Photosynthetic pigments and photosynthetic apparatus
   C. Light reactions of purple photosynthetic bacteria, green sulphur bacteria and cyanobacteria
   D. Dark reaction: Calvin Benson cycle and reductive TCA

3. Inorganic metabolism [8]
   A. Assimilatory pathways
      i. Assimilation of nitrate
      ii. Ammonia fixation
      iii. Biological nitrogen fixation – Mechanism for N2 fixation and protection of nitrogenase
      iv. Assimilation of sulphate
   B. Dissimilatory pathways
      i. Nitrate as an electron acceptor (Denitrification in *Paracoccus denitrificans*)
      ii. Sulphate as an electron acceptor

   C. Lithotrophy - Enlist organisms and products formed during oxidation of Hydrogen, carbon monoxide, Ammonia, Nitrite, Sulphur, Iron.

Practical based on Paper III

1. Isolation of Phenol degraders and estimation of residual phenol by 4-amino antipyrene method
2. Estimation of β-galactodidase activity in induced and non- induced cells of *Escherichia coli*
3. To study catabolite repression by diauxic growth curve

4. Protein estimation by Lowry's method
5. Isolation of bioluminiscent bacteria from fish
6. Study of biochemical pathway and study of end products of enzymes in characterization of micro-organisms.
   A. Detection of lysine decarboxylase enzyme.
   B. Oxidative and fermentative utilization of glucose by microbes.
   C. Phosphatase activity detection-qualitative and quantitative.
   D. Detection of Penicillinase activity.
   E. Detection of homo and mixed acid fermentation.
7. Estimation of uric acid.
8. Isolation of mitochondria and assay for ETC activity

Text books

1. Stanier.R.Y., Ingrahm,J.L., Wheelis, M.L., Painter, R.R,.(1987) General Microbiology, 5th edition, The Macmillan press Ltd
2. Conn , Stmpf, P. K., Bruening, G. R. H.(1987) Outlines of Biochemistry, 5th edition, John Wiley & sons
3. Gottschalk,G., (1985), Bacterial Metabolism, 2nd edition, Springer Verlag
4. White, D., (1995), The Physiology and Biochemistry of Prokaryotes, 3rd edition, Oxford University Press
5. Nelson, D, Cox, M,(2005), Lehninger Principles of biochemistry,4th edition, W. H. Freeman and Company

Reference books

1. Voet, D & Voet, J. G., (2004), Biochemistry, 3rd edition, John Wiley& Sons Inc
2. Zubey, G. L (1996), Biochemistry, 4th edition, Wm. C. Brown publishers
3. Zubey, G. L (1996), Principles of Biochemistry, Wm. C. Brown publishers

PAPER IV: BIOPROCESS TECHNOLOGY

Unit	Brief Topic Description	No of Lectures
I	Upstream Processing	30
II	Downstream Processing	30
III	Traditional Industrial Fermentations	30
IV	Advances in Bioprocess Technology	30
	Total	120

I. UNIT 1: UPSTREAM PROCESSING (30)

1. Industrial Strains [7]
   A. Strain improvement (One example of each method of strain improvement for primary and secondary metabolite)
   B. Preservation of industrial strains

2. Fermentation Media Design [3]
   A. Buffers, precursors, steering agents, inducers, inhibitors, antifoam agents, trace elements, Animal cell culture media
   B. Media Optimizations – general principles

3. Fermentation Equipments [10]
   A. Construction material
   B. Scale of operation (Lab, Bench scale, pilot plant, production level)
   C. Mode of operation (Batch, fed-batch, semi-continuous, continuous, SSF)
   D. Power Input for mixing (mechanical, hydrodynamic and pneumatic)
   E. Types of fermentors - typical constructional features and their importance in the specific processes, brief review of other supporting services or equipments used for process operations
      i. Mechanical - Waldhof fermenter, rotating disc fermenter, trickling generator,
      ii. Hydrodynamic- deep-jet fermenter
      iii. Pneumatic - air-lift fermenter, bubble-cap fermenter, cylindro-conical vessels, acetator, cavitator.
      iv. Animal cell culture reactors.
      v. Photo-bioreactor, tower and packed tower fermenters, cyclone column.
4. Fermentation Process Operations [10]
   F. Aseptic operation and containment
   A. Sterilization & maintenance of aseptic conditions - vessels, medium, additives, air
   B. Aseptic transfer of inoculum
   C. Process parameter monitoring and control
      i. Temperature, flow, pressure, dissolved oxygen, foam, inlet and exit gases, pH
      ii. Control systems – manual and automatic (only list)

II UNIT 2 – DOWNSTREAM PROCESSING (30)

1. Fermentation Product Recovery [10]
   A. Criteria for choice of recovery process
   B. Biomass separation from fermentation media
      i. Precipitation
      ii. Filtration, filter aids, plate frame and rotary vacuum filters
      iii. Centrifugation - Cell aggregation and flocculation, types of centrifuges
   C. Cell Disruption for intracellular products
   D. Solvent extraction and recovery
   E. Chromatography
   F. Membrane processes
   G. Drying
   H. Crystallization
   I. Whole broth processing

2. Industrial Effluent Treatment [3]
   A. Distillery Effluents
   B. Pharmaceutical Effluents

3. Fermentation Economics - Isolation, strain improvement, market potential, equipment, media, air sterilization, temperature control, aeration and agitation, recovery, water recycling, effluent treatment. [2]

4. Quality Assurance [5]
   Definitions---GMP, QA, QC
   QC of raw materials, in-process items, finished products, packaging materials, labels
   Sterility assurance and testing
   Microbiological Assays

5. Bioinstrumentation - Principles, working and applications of [10]
   A. Spectroscopic techniques
   B. Electron spin resonance (ESR) spectroscopy
   C. Nuclear magnetic resonance (NMR) spectroscopy
   D. Circular dichroism (CD) spectroscopy
   E. Mass spectroscopy
   F. Spectrophotometry (U.V., Visible, I. R)
   G. Fluorimetry
   H. Flame photometry
   I. Radioisotopes and autoradiography

III UNIT 3: TRADITIONAL INDUSTRIAL FERMENTATIONS (30)

1. Beer [2]
2. Wine [2]
3. Alcohol from molasses [1]
4. Vinegar (acetator [1]
5. Penicillins and semisynthetic penicillins [3]
6. Streptomycin [1]
7. Vitamin B12 from Propionibacterium [2]

8. Glutamic Acid (direct) [1]
9. Baker's and Brewer's yeast [2]
10. Citric acid - Stationary culture [2]
11. Mushrooms (Agaricus bisporus) [2]
12. Biotransformation of Steroids (List of organisms and steroids transformed) [1]
13. Vaccines -General Manufacturing aspects and quality control [3]
14. Ergot Alkaloids [2]
15. Probiotic foods & neutraceuticals [2]
16. Amylase enzyme production (Solid state fermentation) [1]
17. Microbial polysaccharides [2]

IV. UNIT 4: ADVANCES IN BIOPROCESSES (30)

1. Enzyme Technology [6]
   A. Enzyme Immobilization methods
   B. Applications in therapeutic uses, Analytical uses and Industrial uses

2. Animal Cell Lines [6]
   Methods of cultivation and establishment of cell lines
   Large scale cultivation procedures
   Applications in production of tPA, Blood facor viii and erythropoietin

3. Plant Tissue Culture [6]
   Methods of cultivation of organ culture, callus culture and cell suspension culture
   Application in
   Agriculture (Disease resistant plants, virus free plants)
   Horticulture (Micropropagation)
   Industry (secondary metabolites production)
   Transgenic plant (Insect resistant plants)

4. Commercial Products from Recombinant Microorganisms - Indigo, Bioflavours, Melanin, Biopolymer, Polyhydroxyalkanoate, Rubber, Recombinant proteins of high value [5]

5. Synthesis of Nanomaterials by Biological methods
   Applications in biotechnology and medical field [2]

6. Intellectual Property Rights [5]
   A. Introduction to IPR – What is intellectual property? Genesis of IPR (WIPO, GATT, TRIPs)
   B. Types of intellectual property –
      a. Patents b. Copyright c. Trademark d. Trade secret e. Plant varieties protection act
   C. Patents –
      a. Patent system terminologies
      b. Categories of patents
      c. Preparation of patent
         i. Criteria for patenting
         ii. Patent specification – standard format
         iii. Typical patenting procedure
         iv. Rights of a patentee

d. Uses of patent system

D. Recent trends of biotechnological and microbiological patents - Patenting of life forms (viz. multicellular organisms, DNA sequences)

Text Books

1. Casida L. E., "Industrial Microbiology" 2009 Reprint, New Age International (P) Ltd, Publishers, New Delhi
2. Glick B.R. & Pasternak J. J., 2003, "Molecular Biotechnology, Principles and Applications of Recombinant DNA", 3rd Edition, ASM Press, Washington, USA
3. Stanbury P. F., Whitaker A. & HaII--S. J., 1997, "Principles of Fermentation Technology", 2nd Edition, Aditya Books Pvt. Ltd, New Delhi.
4. Crueger W. and Crueger A. 2000 "Biotechnology -"A Textbook of Industrial Microbiology", 2nd Edition, Panima Publishing Corporation, New Delhi.
5. Prescott and Dunn's ''Industrial Microbiology''.1982 4th Edition, McMillan Publishers
6. Ratledge & B. Kristinsen 2nd edn 2006. ''Basic Biotechnology''. Cambridge University Press
7. R. C. Dubey, 2005 A Textbook of ''Biotechnology'' S. Chand and Company, New Delhi
8. Indu Shekar Thakur 2006 ''Industrial Biotechnology'' Problems and Remedies, I K International Pvt Ltd
9. S. K. Kulkarni, Nanotechnology: Principles and Practices, Capital Publishing Co.

Reference Books

1. Peppler, H. J. and Perlman, D. (1979), "Microbial Technology''. Vol 1 & 2, Academic Press
2. U. Satyanarayana 2005. ''Biotechnology''. Books and Allied (P) Ltd
3. Agrawal A. K. and P. Parihar 2005. ''Industrial Microbiology''- Fundamentals and Application AGRIBIOS (India)
4. H. A. Modi, 2009. ''Fermentation Technology'' Vols 1 & 2, Pointer Publications, India
5. Okafor Nkuda 2007 ''Modern Industrial Microbiology and Biotechnology'', Science Publications Enfield, NH, USA.

Practical Syllabus Based On Paper IV

1. Comparison of amylase activity of *Aspergillus* culture grown in liquid medium and on solid substrate.
2. Chemical and Bioassay of Penicillin
3. Bioautography and Bioassay of Vitamin B12.
4. Isolation of lactic acid bacteria from Probiotic foods.
5. Sugar and alcohol tolerance of Saccharomyces cerevesiae.
6. Ethanol production from jaggery, chemical estimation of sugar by Cole's Method , alcohol produced by dichromate method, efficiency of fermentation
7. Sterility testing of injectable (D/W ampoules)
8. Estimation of BOD and COD from distillery effluent.
9. Immobilization of enzyme---preparation of alginate-enzyme/culture beads, qualitative and quantitative activity estimation, viable count of bead culture.
10. Plant tissue culture (Demonstration)
11. Visits
    A. Antibiotic production plant or Pharmaceutical Industry
    B. Vaccine Production Plant (Animal/ Human)
    C. Application of Recombinant DNA in Industrial Production

Suggested Examination Pattern

1. Students opting for 6 Units of Microbiology (Major) at T Y B Sc level will study Papers I, II, III, IV of 100 marks each and 4 practicals based on these papers of 50 marks each.
2. Students opting for 3 Units of Microbiology at T Y B Sc level will study Papers I & II of 100 marks each and two practicals based on these papers of 50 marks each.
3. Quiz and spots shall be based exclusively on the practical syllabus.
4. Theory Examination - Four papers of 100 marks each of 3 hr duration as per the prescribed university pattern for B.Sc. should be followed. Each paper should cover entire syllabus in proportionate manner, using number of lectures assigned to the topic as a rough guideline.
5. Practical Examination
   A. 3 Units: - As per university directives, should be of 100 marks; two practicals of 50 marks each. The following pattern of practical exam is suggested.

Practical 1		Practical 2	
Technique Problem 1 Technique Problem 2	20 10	Medical	40
Spots /Quiz	10	Rapid diagnostics	10
Journal	10		
Total	50	Total	50

   i. Techniques and chemical estimation shall be based on all relevant practicals including demonstrations / group experiments based on two papers.
   ii. Practical examination will be held on 3 consecutive days between 10.00 a.m. to 4.00 p.m. with half hour lunch break.
   iii. Laboratory journal is to be duly certified by the Head, Department of Microbiology. Examiners are required to sign the journal and report at the end of examination.

   B. 6 Units - As per university directives, should be of 200 marks; four practical of 50 marks each. The following pattern of practical exam is suggested.

Practical 1		Practical 2		Practical 3		Practical 4	
Technique [40]		Medical	40	Chemical Estimation	30	Bioassay	40
Problem 1 Problem 2	25 15	Rapid diagnostics	10	Journal	10	Quiz	10
Journal	10			Spots	10		
Total	50	Total	50	Total	50	Total	50

   i. Techniques and chemical estimation will be based on all relevant practical including demonstrations / group experiments based on all 4 paper practical.
   ii. Practical examination will be held on 3 consecutive days between 10.00 a.m. to 5.00 p.m. with half hour lunch break.
   iii. Laboratory journal is to be duly certified by the Head, Department of Microbiology. Examiners are required to sign the journal and report at the end of examination.