JAI HIND COLLEGE
BASANTSING INSTITUTE OF SCIENCE
&
J.T.LALVANI COLLEGE OF COMMERCE
(AUTONOMOUS)

"A" Road, Churchgate, Mumbai - 400 020, India.

Affiliated to
University of Mumbai

Program: B.Sc

Proposed Course: Microbiology

Semester V

Credit Based Semester and Grading System (CBCS) with effect from the academic year 2020-21

T.Y.B.Sc. Microbiology Syllabus

Academic Year 2020-2021

Semester 5			
Course Code	**Course Title**	**Credits**	**Lectures /Week**
SMIC501	**Microbial Genetics and Cell Biology**	**04**	**04**
Unit 1	Mutation and DNA Repair		
Unit 2	Genetic Exchange & Homologous Recombination		
Unit 3	Cell Biology		
Unit 4	Cell Signalling		
SMIC502	**Medical Microbiology & Immunology: Part-I**	**04**	**04**
Unit 1	Bacterial Strategies for Evasion and Study of a Few Diseases (G.I and Urinary Tract)		
Unit 2	Study of Skin Infections and Respiratory Tract		
Unit 3	General Immunology-I		
Unit 4	General Immunology-II		
SMIC503	**Microbial Biochemistry: Part – I**	**04**	**04**
Unit 1	Biological Membranes & Transport		
Unit 2	Bioenergetics & Bioluminescence		
Unit 3	Methods of Studying Metabolism & Catabolism of Carbohydrates		
Unit 4	Fermentative Pathways and Anabolism of Carbohydrates		
SMIC504	**Bioprocess Technology: Part – I**	**04**	**04**
Unit 1	Strain Improvement and Inoculum Development		
Unit 2	Types of Fermenters and Sterilization		
Unit 3	Scale up, Scale down of Fermentation and Downstream Processes		
Unit 4	Traditional Fermentations		
SMIC5PR1		**04**	**08**
SMIC5PR2		**04**	**08**

SEMESTER V – THEORY

Course: SMIC 501	**Microbial Genetics and Cell Biology (Credits : 04Lectures/Week:04)**	**60L**
Learning Objectives:	➢ To study molecular basis and types of mutation, their cause, effect and DNArepair ➢ To study various mechanisms of gene transfer andgenetic recombination inbacteria. ➢ To study the eukaryotic cell and understand the role of variouscell organelles ➢ To understand the mechanisms of cellsignalling	
Outcomes:	On completion of the course, students will: ➢ Learn the concepts of mutations and screening ofmutants ➢ Understand the mechanisms of DNA repair andrecombination ➢ Study the transfer of genetic material in bacteria and genemapping ➢ Know the structure and role of cellular organelles ineukaryotes ➢ Understand the basic elements and signalling pathways in acell	
Unit I	**Mutation and DNA Repair**	**15 L**
1.1	**Mutation** **Terminology:** Alleles, homozygous, heterozygous, genotype, phenotype, Somatic mutation, Germline mutation, Gene mutation, Chromosome mutation, phenotypic lag, hotspots and mutator genes.	**01**
1.2	**Fluctuation test**	**01**
1.3	**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.	**03**
1.4	**Causes of mutation:** a. Natural/spontaneous mutation-- replication error,depurination, deamination. b. Induced mutation: principle and mechanism withillustrative diagramsfor i. Chemical mutagens - base analogues, nitrous acid,hydroxyl amine, intercalating agents and alkylatingagents. ii. Physicalmutagen iii. Biological mutagen (onlyexamples)	**04**
1.5	**Ames test**	**01**
1.6	**Detection of mutants**	**01**

1.7	**DNA Repair** i. Mismatchrepair ii. Lightrepair iii. Repair of alkylationdamage iv. Base excision repair v. Nucleotide excisionrepair vi. SOSrepair	**04**
Unit II	**Genetic Exchange & Homologous Recombination**	**15 L**
2.1	**Genetic analysis of Bacteria**	**01**
2.2	**Gene transfer mechanisms in bacteria** **Transformation** i. Introduction andHistory *ii.* Types of transformation in prokaryotes--Natural transformation in *Streptococcus pneumoniae, Haemophilus influenzae,* and *Bacillussubtilis.* iii. Mapping of bacterial genes usingtransformation. iv. Problems based ontransformation.	**03**
2.3	**Conjugation** i. Discovery of conjugation inbacteria ii. Properties of F plasmid/Sexfactor iii. The conjugationmachinery iv. Hfr strains, their formation and mechanism ofconjugation v. F' factor, origin and behavior of F' strains,Sexduction. vi. Mapping of bacterial genes using conjugation (Wolmanand Jacobexperiment). vii. Problems based onconjugation	**05**
2.4	**Transduction** i. Introduction anddiscovery ii. Generalizedtransduction iii. Use of Generalized transduction for mappinggenes iv. Specializedtransduction v. Problems based ontransduction	**03**
2.5	**Recombination in bacteria** i. General/Homologousrecombination ii. Molecular basis ofrecombination iii. Holliday model of recombination (Single strand DNA break modelonly) iv. Enzymes required forrecombination v. Site –specificrecombination	**03**

Unit III	Cell Biology	15 L
3.1	**Overview of Eukaryotic cell** Structure and Function of cell organelles (Tabulate)	02
3.2	Study of Cell Wall of yeasts, plant and fungi (Comparison)	02
3.3	**Cytoskeleton** a. Overview of the majorfunctions b. Structure and compositionof: i. Microtubules ii. Intermediate Filaments iii. Microfilaments	06
3.4	Endoplasmic Reticulum and Protein segregation	02
3.5	Golgi Complex and cell secretion	03
Unit IV	**Cell Signalling**	15 L
4.1	Basic elements of Cell Signalling System	02
4.2	A Survey of Extracellular Messengers & their receptors	02
4.3	G-Protein Coupled Receptors & their Second Messengers (GPRs, cAMPs & Phosphatidyl Inositol)	05
4.4	Protein Tyrosine Phosphorylation as a mechanism for signal Transduction	04
4.5	Role of calcium as an intracellular messenger (calcium binding protein, calmodulin)	02

Textbooks and References:

1 Russell P. J., iGenetics – A Molecular approach, Pearson Education, Inc., 2ndEd., 2006.

2 Pierce B.A., Genetics: A conceptual approach, New York:W.H, 3rdEd.,2008.

3 Lehninger A. L., Nelson, D. L., & Cox, M. M., Lehninger principlesof biochemistry, New York: Worth Publishers, 5thEd.,2008.

4 Tamarin R. H, Principles of genetics, Tata McGraw Hill,2004.

5 Madigan M. T., Martinko J. M., Brock biology of microorganism, Upper Saddle River, NJ: Prentice Hall/Pearson Education, 12th Ed.,2009.

6 Fairbanks & Anderson., Genetics, Wadsworth Publishing Company,1999.

7 Willey J. M., Sherwood L., Woolverton, C. J., Prescott, Harley & Klein's Microbiology, New York: McGraw-Hill, 7thEd.,2008.

8 Weaver R., Molecular biology, McGraw Hill international edition, 3rdEd.,2004.

9 Trun N and TrempyJ. , Fundamental bacterial genetics, Blackwell Publishing,2004.

10 Karp G., Cell and Molecular Biology: Concepts and Experiments,Wiley International, 5th Ed., 2008.

11 Snustad S., Principles of genetics, John Wiley & sons, Inc., 3rd Ed., 2003. 12 Lewin B., Genes IX, Jones and Bartlett publishers, 2007.

13 Watson J.D., Molecular biology of the gene, Pearson Education, Inc, 5th Ed., 2004.

Course: SMIC 502	Medical Microbiology & Immunology: Part-I (Credits : 04, Lectures/Week:04)	60L
Learning Objectives:	➢ Study the virulence mechanisms ofbacteria ➢ To learn about respiratory tract, urinary tract, skin and G.I tract infections ➢ Understand the basic concepts of the immunesystem ➢ To learn the principles and methods of serologicaltests	
Outcomes:	On completion of the course students will be able to: ➢ Give details of the virulence factors of the pathogen and how it influences the pathogenesis and clinical features of adisease ➢ Comment on the different pathogens and the disease caused bythem w.r.t transmission, pathogenesis and clinical manifestation , Lab diagnostic procedures and prophylactic measures ➢ Understand the importance of antigen, antibody , cytokines, antigen presenting cells , MHC and their role in adaptiveimmunity ➢ Describe the serological methods used indiagnosis.	
Unit I	**Bacterial Strategies for Evasion and Study of a Few Diseases**	**15 L**
1.1	**Study of virulence mechanisms in bacteria** i. Pathogenicityislands ii. Bacterial virulencefactors iii. Adherencefactors a. Invasion of host cells andtissues b. Toxins iv. Exotoxins a. Exotoxins associated with diarrhoeal diseases and food poisoning b. LPS of gram negativebacteria v. Enzymes a. Tissue degradingenzymes b. IgA1proteases vi. Antiphagocyticfactors vii. Intracellularpathogenicity viii. Antigenic heterogeneity ix. The requirement foriron x. Bacterial SecretionSystem xi. Role of BacterialBiofilms	**05**
1.2	**Study of gastrointestinal tract infections** (w.r.t. Cultural Characteristics of the etiological agent, pathogenesis & clinical features, laboratory diagnosis, treatment and prevention only) i. Infections due to diarrheagenic *E.coli* strains *ii.* Enteric fever-*Salmonella* iii. Shigellosis iv. Cholera v. Rotavirusdiarrhea vi. Dysentery due to *Entamoebahistolytica*	**08**

1.3	**Study of urinary tract infections**	**02**
Unit II	**Study of few diseases** (w.r.t. Cultural characteristics of the etiological agent, pathogenesis & clinical features, laboratory diagnosis, treatment and prevention only)	**15 L**
2.1	**Study of skin infections** *i.* Pyogenic skin infections caused by *S.aureus, S.pyogenes* and *Pseudomonas aeruginosa* ii. Leprosy iii. Fungal infections-Candidiasis iv. Viral Infections- Herpessimplex	**07**
2.2	**Study of A Few Infectious Diseases of the Respiratory Tract** i. *S. pyogenes*infections ii. Influenza iii. Tuberculosis *iv.* Pneumonia caused by *K.pneumoniae* v. Emerginginfections: MERS, SARS- COV2	**08**
Unit III	**General Immunology – I**	**15 L**
3.1	**Antigens** i. Immunogenicity versusantigenicity Concepts -Immunogenicity, Immunogen, Antigencity, Antigen, Haptens. Haptens as valuable research and diagnostic tools ii. Factors that influence immunogenicity - Foreignness, Molecular size, Chemical composition, Heterogeneity, Susceptibility of antigen to be processed and presented, Contribution of the biological system toimmunogenicity: Genotype of the recipient, Immunogen dosage, Route of administration iii. Adjuvants, Liposomes andVirosomes iv. Epitopes / antigen determinants - General concept, Characteristic properties of B - cell epitopes, concepts of sequential and non-sequential epitopes (with only on example each). Properties of B - cell and T - cell epitopes. Comparison of antigen recognition by T cells and B cells Thymus dependent and Thymus independent antigens Endogenous and exogenousantigens v. Types of antigens – heterophile antigens, isophile antigens, sequestered antigens, super antigens, bacterial and viral antigens	**05**

3.2	**Immunoglobulins** i. Immunoglobulins – basic structure of Immunoglobulins, heterodimer; types of heavy and light chains; constantandvariable regions, Immunoglobulin domains-hinge region. Basic concepts - hypervariable region, complementarity - determining regions (CDRs), framework regions (FRs) and their importance. Antibody Mediated Effector functions ii. Immunoglobulin classes and biological activities - Immunogloublin G, Immunogloublin M, Immunogloublin A, Immunogloublin E, Immunogloublin D, (including diagrams) iii. Antigenic determinants on immunoglobulins – isotypes, allotypes, idiotypes. iv. Immunoglobulin Superfamily v. Monoclonal antibodies – Production and their applications	**08**
3.3	**Cytokines** i. Introduction to cytokines ii. Attributes of cytokines iii. Biological functions of cytokines iv. Cytokine related diseases v. Cytokine based therapies	**02**
Unit IV	**General Immunology – II**	**15 L**
4.1	**Major histocompatibility complex** i. General organization of the MHC ii. Three major classes of MHC encoded molecules iii. The basic structure and functions of Class I and Class II MHC Molecules iv. MHC: Polymorphic and Polygenic v. Peptide binding by Class I and Class II MHC molecules vi. HLA typing and its significance	**04**
4.2	**Antigen presenting cells** i. Types of APC's ii. Endogenous antigens: The cytosolic pathway iii. Exogenous antigens: The endocytic pathway	**03**
4.3	**Antigen Antibody reactions** i. Precipitation reactions – Immunoelectrophoresis ii. Agglutination reactions - haeme-agglutination, Bacterial agglutination, passiveagglutination, agglutination inhibition, Complement fixation iii. Radioimmunoassay (RIA), iv. Enzyme Linked Immunosorbent Assay - indirect, competitive and sandwich ELISA, Chemiluminescence,	**08**

	Elispot assay v. Immunofluorescence- Direct and indirect, Immuno precipitation vi. Flow cytometry and Fluorescence. vii. Western blotting viii. Immunoelectron Microscopy	

Textbooks and Additional References:

1. Karen C., Morse A., Jawetz, Melnick and Adelberg's Medical Microbiology,Mc Graw Hill Education Lange publication, 26th Ed.,2016.
2. Ananthanarayan&Panicker's, Textbook of Microbiology,Universities Press(India) Pvt Ltd. , 10th Ed.,2017.
3. KindtT.J.,Goldsby R.A., Osborne B.A., Kuby Immunology, W H Freemanand Company, 6th Ed.,2007.
4. Pathak S., Palan U., Immunology: Essential & Fundamental, CapitalPublishing Company, 3rd Ed.,2011.
5. Khan F., the Elements of Immunology, Pearson Education, 2009.

Reference books / Internet references:

1. Owen A. J., Punt J.,Stanford S.A., KubyImmunology,W H Freemanand Company, 7th Ed.,2013.
2. Ananthanarayan&Panicker's, Textbook of Microbiology, Universities PressPvt Ltd, 8th Ed.
3. Baron Samuel , Medical Microbiology, 4th Ed.
4. http://www.ncbi.nlm.nih.gov/books/NBK7627/
5. http://www.macmillanlearning.com/catalog/static/whf/kuby/of the gene", 5th Ed.

Course Code: SMIC503	Microbial Biochemistry: PART-I (Credits : 04Lectures/Week:04)	60L
Learning Objectives:	➢ To study uptake, various intermediary metabolic processes and methods to study metabolism both invitro andinvivo ➢ To study carbohydrate metabolism and to understand the principles of energy generation by different physiological groups oforganisms. ➢ To study the mechanisms of energy generation by using electrontransport systems and gaining knowledge of energyconservation. ➢ Learning anabolic processes through concepts of biosynthesis,and polymerization namely glycogen and peptidoglycanbiosynthesis	
Outcomes:	On completion of the course, students will: ➢ Study solute transport and energymetabolism ➢ Know various biochemicalpathway ➢ Understand the concept of microbial metabolism ➢ Learn Catabolism and anabolism of carbohydrates	
Unit I	**Biological Membranes & Transport**	**15 L**
1.1	**Composition and architecture of membrane** i. Lipids and properties of phospholipidmembranes ii. Integral & peripheral proteins & interactions withlipids iii. Permeability iv. Aquaporins v. Mechanosensitivechannels vi. Siderophores	**02**
1.2	**Methods of studying solute transport** i. Use of wholecells ii. Liposomes iii. Proteoliposomes	**02**
1.3	**Solute transport across membrane** i. Passive transport and facilitated diffusion by membrane proteins ii. Co-transport across plasma membrane - (Uniport, Antiport, Symport) iii. Active transport & electrochemicalgradient iv. Ion gradient provides energy for secondary activetransport a. Lactose transport v. ATPases and transport (only Na-KATPase)	**08**

	vi. Shock sensitive system – Role of bindingproteins a. Maltose uptake (Diagram anddescription) b. Histidine uptake (Diagram anddescription) vii. Phosphotransferasesystem viii. Schematic representation of various membranetransport systems inbacteria.	
1.4	**Other examples of solute transport:** i. Iron transport: A specialproblem ii. Assembly of proteins into membranes and proteinexport iii. Bacterial membrane fusion central to many biological processes	**03**
Unit II	**Bioenergetics & Bioluminescence**	**15L**
2.1	**Biochemical mechanism of generating ATP:** Substrate-Level-Phosphorylation, Oxidative Phosphorylation & Photophosphorylation	**01**
2.2	**Electron transport chain** i. Universal Electron acceptors that transfer electrons toE.T.C. ii. Carriers inE.T.C. a. Hydrogen carriers – Flavoproteins,Quinones b. Electron carriers – Iron Sulphur proteins,Cytochromes. iii. MitochondrialETC a. Biochemical anatomy ofmitochondria b. Complexes in MitochondrialETC c. Schematic representation of MitochondrialETC.	**03**
2.3	**Prokaryotic ETC** i. Organization of electron carriers inbacterial. a. Generalized electron transport pathway inbacteria b. Different terminaloxidases ii. Branched bacterialETC iii. Pattern of electron flow in *E. coli* - aerobic andanaerobic *iv.* Pattern of electron flow in *Azotobactervinelandii*	**03**

2.4	**ATP synthesis** i. Explanation of terms – Proton motive force, Proton pump, Coupling sites, P:O ratio, Redox potential (definition of Standard reductionpotential) ii. Free energy released during electron transfer from NADHto iii. Chemiosmotic theory (onlyexplanation) iv. Structure & function of Mitochondrial ATPsynthase v. Structure of bacterial ATPsynthase vi. Mechanism by Rotationalcatalysis vii. Inhibitors of ETC, ATPase anduncouplers	**03**
2.5	**Other modes of generation of electrochemical energy** i. ATPhydrolysis ii. Oxalate formateexchange iii. End product efflux, Definition, Lactateefflux iv. Bacteriorhodopsin: - Definition, function as proton pump and significance	**03**
2.6	**Bioluminescence** i. Brief survey of bioluminescentsystems ii. Biochemistry of lightemission iii. Schematicdiagram iv. Significance /Application	**02**
Unit III	**Studying Metabolism & Catabolism of Carbohydrates**	**15 L**
3.1.	**Experimental Analysis of metabolism**	**03**
	i. Goals of thestudy ii. Levels of organization at which metabolism isstudied iii. Metabolicprobes. iv. Use of radioisotopes inbiochemistry a. Pulselabelling b. Assay and study of radiorespirometry to differentiate EMP&ED v. Use of biochemical mutants vi. Sequentialinduction	

3.2	**Catabolism of Carbohydrates** i. Breakdown of polysaccharides– Glycogen, Starch,Cellulose ii. Breakdown of oligosaccharides – Lactose, Maltose, Sucrose, Cellobiose. iii. Utilization of monosaccharides – Fructose,Galactose iv. Major pathways – (with structure andenzymes) a. Glycolysis(EMP) b. HMP Pathway - Significance of thepathway c. EDpathway d. TCA cycle - Action of PDH, Significance ofTCA e. Incomplete TCA in anaerobicbacteria f. Anapleroticreactions g. Glyoxylatebypass	**10**
3.3	**Amphibolic role of EMP; Amphibolic role of TCA cycle**	**01**
3.4	**Energetics of Glycolysis, TCA and ED pathway –** Balance sheet only. Format as in Lehninger (2.5 ATP/NADH and 1.5 ATP /FADH2) (Based on this format make balance sheet for Glycolysis -Lactic acid and Alcohol fermentation and for ED pathway)	**01**
Unit IV	**Fermentative Pathways & Anabolism of Carbohydrates**	**15 L**
4.1	**Fermentative pathways (with structures and enzymes)** i. Lactic acidfermentation a. Homofermentation b. Heterofermentation ii. Bifidum pathway iii. Alcoholfermentation a. By ED pathway inbacteria b. By EMP inyeasts	**04**
4.2	**Other modes of fermentation in microorganisms** i. Mixedacid ii. Butanediol iii. Butyricacid iv. Acetone-Butanol v. Propionic acid (Acrylate and succinate propionatepathway)	**05**
4.3	**Anabolism of Carbohydrates** i. General pattern of metabolism leading to synthesis of a cellfrom glucose ii. Sugarnucleotides iii. Gluconeogenesis (onlybacterial) iv. Biosynthesis of glycogen v. Biosynthesis ofPeptidoglycan	**06**

Text Books :

1. Stanier R. Y., M. Doudoroff& E. A. Adelberg., General Microbiology,The Macmillanpress Ltd, 5th Ed.
2. Conn E.E., P. K .Stumpf G. Bruening& R. Y. Doi., Outlines of Biochemistry, John Wiley &Sons. New York, 5th Ed.,1987.
3. Gottschalk G., Bacterial Metabolism,Springer Verlag, 2nd Ed.,1985.
4. White D., The Physiology and Biochemistry of Prokaryotes, Oxford University Press, 3rd Ed., 1995.
5. Nelson D. L. & M.M. Cox, Lehninger, Principles of biochemistry.,W. H. Freemanand Company,4th Ed., 2005.
6. Rose A.H.,Chemical Microbiology, Butterworth-Heinemann, 3rd Ed,1976.
7. Zubay G. L, Biochemistry, Wm. C. Brown publishers, 4th Ed.,1996.
8. Mathews C.K., K.E. van Holde, D.R. Appling, S, J, Anthony-Cahill, Biochemistry, Pearson, 4th Ed.,2012.
9. Wiloson& Walker, Principles and Techniques of Biochemistry and MolecularBiology. Cambridge University press. 4th Ed.

Reference Books

1. Zubay G. L, Principles of Biochemistry, Wm. C. Brown publishers, 1996.
   Cohen G.N.,Microbial Biochemistry, Springer, 2nd Ed., 2011

Course: SMIC 504	Bioprocess Technology: Part – I (Credits : 04Lectures/Week:04)	60L
Learning Objectives:	➢ To develop the learner's ability to study the techniques used in the different phases of industrial microbiology such as strainimprovement, basic fermentation equipment& its sterilization aspects, different types offermenters ➢ To study the principles and describe the main steps and processes in the industrial production of beverages andenzymes ➢ The learner is provided with the details of productions of important traditional fermentationproducts.	
Outcomes:	On completion of the course students will be able to : ➢ Understand the role and methods of 'Strain improvement ' inindustry ➢ Describe the design of bioreactors for different applications andits processparameters ➢ Explain the methods used in downstreamprocessing ➢ Describe the industrial production of various alcoholicbeverages, vinegar, amylase andbiogas.	
Unit I	**Strain Improvement and Inoculum Development**	**15 L**
1.1	**Strain improvement** The improvement of industrial microorganisms Mechanisms of control for biosynthesis	**01**
1.2	i. Types of microbialmutants ii. Practical implications of microbialmutants iii. Isolation of microbialmutants	**03**
1.3	**Directed selection** i. Isolation of auxotrophicmutants ii. Isolation of mutants requiring noinducer iii. Isolation of mutants resistant to end productrepression iv. Isolation of mutants resistant to cataboliterepression	**04**
1.4	i. Selection of mutants producing high yield ofprimary metabolites ii. Selection of mutants producing secondarymetabolites	**01**
1.5	**Classical strain improvement by recombination** i. FungalParasexuality ii. Protoplast fusion a. Intraspecificrecombination b. Interspecifichybridization c. Advantages of protoplast fusiontechnique d. Transformation and Transfection ofprotoplasts e. Egs of commercial application	**03**

1.6	**Inoculum Development** i. Introduction ii. Criteria for transfer ofinoculums iii. Development of inocula for yeastprocesses iv. Development of inocula for bacterialprocesses v. Development of inocula for mycelialprocesses vi. Aseptic inoculation of plantfermenters	**03**
Unit II	**Upstream Processing – II**	**15 L**
2.1	**Types of Fermenters** Alternative vessel designs i. Air lift and modifiedairlift ii. Bubblecolumn iii. Fluidised bedreactor iv. Packed bedcolumns v. Deepjet vi. Towerfermenter vii. Bubble capfermenter viii. Photobioreactors	**06**
2.2	**Sterilization of fermentation media and fermenter** i. Introduction ii. Steam sterilization of media (concept of delfactor) iii. Classical technique of steamsterilization a. Batchsterilization b. Continuoussterilization iv. Filter sterilization of fermentationmedia v. Media sterilization by chemicalagents vi. Media sterilization byradiation vii. Sterilization of theFermenter viii. Filter sterilization ofair	**06**
2.3	**Instrumentation and control** Introduction to sensors and its types Measurement and control of: pH, temperature, pressure, foam sensing, dissolved oxygen, inlet and exit gas analysis	**03**
Unit III	**Scale Up, Scale Down and Downstream processes**	**15 L**
3.1	i. Significance of scaleup ii. Criteria used for scaleup iii. Physical & Chemicalfactors iv. Experimental Approach for scale up offermentation v. Scaledown	**05**
3.2	**Downstream processes** i. Removal of Microbial Cells and other solidmatter ii. FoamSeparation iii. Precipitation andFiltration iv. CellDisruption v. Liquid Liquidextraction vi. SolventRecovery vii. Chromatography viii. MembraneProcesses	**10**

	ix. Crystallization x. Whole Broth Processing xi. Effluent Treatment (Self Study)	
Unit IV	**Traditional Fermentations**	**15 L**
4.1	**Wine – Red, White, Champagne and Sherry:** Alcoholic fermentation, composition of grape juice, Sulphur dioxide addition, factors affecting wine fermentation, examples and role of yeasts involved in fermentation, malolactic fermentation, technological aspects of wine making- red, white, champagne, sherry, examples of aroma compounds of wine, types and examples of wine recovery by distillation.	**03**
4.2	**Beer – Ale and Lager:** Elements of brewing process, process details, use of cylindro- conical vessel, primary fermentation, continuous fermentation, aging and finishing, yeasts involved in fermentation.	**03**
4.3	**Alcohol from Molasses:** Introduction, biosynthesis of ethanol, production process- preparation of nutrient solution, fermentation	**02**
4.4	**Vinegar (acetic acid):** Introduction, biosynthesis, generator, production using submerged fermenter, recovery.	**03**
4.5	**Biogas production** Introduction, Composition, Types of substrates, Production process	**02**
4.6	**Amylase production:** Amylase production from bacteria and fungi Amylase and glucoamylase, concentration and purification.	**02**

Textbooks and Additional References:

1. CasidaL. E., Industrial Microbiology ,New Age International (P) Ltd, Publishers, New Delhi, Reprint,2009.
2. Stanbury P. F., Whitaker A. & Hall S. J., Principles of FermentationTechnology, Aditya Books Pvt. Ltd, New Delhi. 2nd Ed.,1997.
3. Stanbury P. F., Whitaker A. & Hall S. J, Principles of FermentationTechnology, 3rd Ed., 2017.
4. Peppler, H. J. and Perlman, D.,MicrobialTechnology,Vol. 1 & 2, Academic Press, 1979.
5. Modi H. A., Fermentation TechnologyVol. 1 & 2, Pointer Publications, India,2009.
6. OkaforNduka, Modern Industrial Microbiology and Biotechnology, Science Publications Enfield, NH, USA,2007.
7. Crueger W. &Crueger A., Biotechnology -A Textbook of Industrial Microbiology,Panima Publishing Corporation, New Delhi.2nd Ed.,2000.
8. Prescott & Dunn's, Industrial Microbiology, McMillan Publishers, 4th Ed.,1982.
9. Waites M.J & Morgan N.L, Industrial Microbiology: Anintroduction.
10. Dubey R.C, A Textbook of Biotechnology, S. Chand and Company, New Delhi,2005.
11. Mcneil B & Harvey L, Practical Fermentation Technology,2008.

SEMESTER V- PRACTICAL

Course Code: SMIC5PR1	**Practicals based on SMIC 501, SMIC 502** **(Credits 04,Practicals /Week: Equivalent to 8 lectures/week)**
Learning Objectives:	➢ To learn effect of mutagenic agents Physical and chemicalon bacteria ➢ To learn techniques used for detection ofmutants ➢ To learn diagnosis ofdiseases
Outcomes:	Upon completion of this course, the students will be able to ➢ Perform the basic techniques related to screening and isolation of UV survivors andmutants ➢ Develop skills to carry out isolation and separation techniquesfor plasmidDNA ➢ Isolate and identify pathogens from pathologicalsamples ➢ Perform and Interpret Immuno-diffusiontechnique
	PRACTICALS: 1. UV survival curve – determination of exposure time leading to90% reduction 2. Isolation of mutants using UVmutagenesis 3. Gradient plate technique (dye resistantmutant) 4. Replica plate technique for selection & characterization of mutants – auxotroph & antibioticresistant 5. Acid faststaining. 6. Identification of *Candida* species using the germ tube test and growth on Chromagar *7.* Study of standard cultures *E. coli, Klebsiella spp., Proteus spp., Pseudomonas spp.,Salmonallatyphi, S. paratyphi A, S. paratyphiB, Shigella spp., S .pyogenes, S.aureus* 8. Identification of isolates obtained from pus, sputum, stool and urine by morphological, cultural and biochemical properties. 9. SRID 10. Ouchterlony diffusiontest 11. Widal test(Demonstration)

Course Code: SMIC5PR2	**Practicals based on SMIC 503, SMIC 504** **(Credits 04: Practicals /Week: Equivalent to 8 lectures/week)**
Learning Objectives:	➢ Study the biochemical activities ofmicroorganisms ➢ To understand industrial application ofmicroorganisms
Outcomes:	Upon completion of this course, the students will be able to: ➢ Studybioluminescence ➢ Isolate LAB based on theirmetabolism ➢ Perform the quantitative/ qualitative analysis ofBiomolecules ➢ Carry out Enzyme production and determination of itsactivity ➢ Learn Techniques used in industrial production ofalcohol
	PRACTICALS: 1 Isolation and study of Bioluminescentorganisms 2 Study of oxidative and fermentativemetabolism 3 Qualitative and Quantitative assay ofPhosphatase 4 Study of Homo -Heterofermentations 5 Isolation and detection of Mitochondria 6 Glucose detection byGOD/POD 7 Alcohol tolerance foryeast 8 Sugar tolerance foryeast 9 Chemical estimation of sugar by Cole'smethod 10 Estimation of alcohol by dichromatemethod 11 Alcoholfermentation a. Preparation and standardization of yeast inoculums foralcohol fermentation b. Laboratory alcohol fermentation using jaggery medium, calculation of efficiency offermentation 12 Production of amylase- Detection, shake flask or solidsubstrate cultivation and detection(Qualitative) 13 Industrialvisit

EVLAUATION SCHEME

Examination			Time Duration	Marks
A. EVALUATION SCHEME FOR THEORY COURSES (4 PAPERS)				
I. Continuous Assessment (C.A.)				**40**
C.A.I Test	MCQ, 1M answers etc		40 mins	20
C.A.II Test	Assignment/Project /Posters/ Presentations etc			20
II. Semester End Examination (SEE)			**2 hours**	**60**
Each Theory Paper				**40+60= 100**
B. EVALUATION SCHEME FOR PRACTICAL COURSES (2 COURSES)				
Semester End Practical Examination				**200**
For Each Practical course				**100**
Practical Course (2 courses)			**3 days**	**200**

Paper Pattern of Semester End Examination (SEE)-

60 Marks (Paper Pattern to be discussed)

Q1/2/3/4 A- 12 Marks Any 3 out of 5

Q1/2/3/4 B- 3 Marks- Any 3 out of 5