



St. Xavier's College (Autonomous) Mumbai

M.Sc. Syllabus For 1st Semester Courses in **Microbiology** (June 2018 onwards)

Contents:

Theory Syllabus for Courses:

SMIC0701 - **VIROLOGY**

SMIC0702 - **GENETICS**

SMIC0703 - **MICROBIAL BIOCHEMISTRY I**

SMIC0704 - **IMMUNOLOGY**

SMIC07PR Practical Syllabus for the following Courses:

LABORATORY AND SCIENTIFIC COMMUNICATION SKILLS

GENETICS

VIROLOGY

MICROBIAL BIOCHEMISTRY

IMMUNOLOGY

Title: VIROLOGY

Course: SMIC0701

LEARNING OBJECTIVES

1. Understand the structure and replication of bacteriophages, plant and animal viruses
2. Understand prions as infectious agents
3. Understand the methods of study of viruses
4. Understand viral evolution and related consequences such as viral emergence

Number of lectures: 60

UNIT 1: INTRODUCTION TO VIROLOGY, TECHNIQUES IN VIROLOGY AND STUDY OF BACTERIOPHAGES **15 LECTURES**

LEARNING OBJECTIVES

1. Understand the architecture and classification of viruses
2. Understand the replication of bacteriophages.
3. Understand the techniques used in virology

1. Introduction to Virology	2L
• Virus architecture and nomenclature	
• Classification of viruses	
2. Techniques in virology	5L
• Measurement of biological activity	
• Viral structural proteins	
• Analysis of genome	
• <i>In situ</i> hybridization, Microarray-based methods	
3. Single/double-stranded DNA and RNA phages of <i>E. coli</i>	8L
• Structure, gene organization and replication of	
i. T4 phage	
ii. T7 phage	
iii. λ Phage	

UNIT 2: STUDY OF PLANT VIRUSES, VIROIDS, AND INSECT VIRUSES **15 LECTURES**

LEARNING OBJECTIVES

1. Understand the structure and replication of plant viruses and viroids.
2. Understand the structure and significance of insect viruses.

1. Impact of plant viruses	2L
• Symptoms of plant viral diseases: macroscopic, histological, cytological	
• Economic impact with the help of one recent example	
• Strategies of plant virus control	

2. Replication strategies of plant viruses	7L
• Strategies to overcome eukaryotic translational constraints	
• Replication strategies of plant viruses with different nucleic acid types with relevant examples	
4. Plant-virus interactions	2L
• Movement of the virus within plants	
• RNA silencing	
5. Agents that resemble plant viruses	2L
• Viroids	
• Satellite viruses and satellite RNAs	
6. Baculoviruses (Insect viruses)	2L
• Significance	
• Viral structure	
• Genome	
• Host range	
• Transmission	

UNIT 3: PATHOGENIC ANIMAL RNA VIRUSES AND PRIONS 15 LECTURES

LEARNING OBJECTIVES

1. Understand the structure and replication of RNA viruses causing significant diseases in animals.
2. Understand prions and prion mediated pathogenesis in humans.

1. Introduction to RNA viruses-	4L
• Constraints faced by RNA viruses in eukaryotic hosts	
• General strategies used by animal RNA viruses	
2. Double stranded RNA viruses- Reoviruses- e.g. Rotavirus	2L
3. Single-stranded RNA viruses with negative sense –Orthomyxoviruses- e.g. Influenza viruses	2L
4. Single-stranded RNA viruses with positive sense-Picornaviruses- e.g. Polio Virus	2L
5. Single-stranded RNA viruses with reverse transcriptase- Retroviruses- Human Immunodeficiency Virus	3L

6. Prions **2L**

- History
- Proteins involved and “Protein only” Hypothesis
- Diseases
 - i. CJD
 - ii. BSE

UNIT 4: PATHOGENIC ANIMAL DNA VIRUSES, VIRUS EVOLUTION, EMERGING VIRUSES AND ANTIVIRALS **15 LECTURES**

LEARNING OBJECTIVES

1. Understand the structure and replication of DNA viruses causing significant diseases in animals.
2. Study virus evolution and the emergence of new and re-emerging animal viruses affecting human health.
3. Study antiviral drugs used to treat/prevent viral diseases

1. Double-stranded DNA viruses- Herpes viruses- e.g. HSV, EBV **2L**

2. Double-stranded DNA-RT viruses-Hepadna viruses- e.g. Hepatitis B virus **3L**

3. Single-stranded DNA virus- Parvoviruses **1L**

4. Viral evolution **4L**

- Host-parasite theory
- r and k replication strategies.
- Quasispecies concept
- Error threshold, lethal mutagenesis, and extinction
- Genetic bottlenecks
- Origin of viruses

5. New and re-emerging animal viruses **2L**

- Evolution, Emergence, and adaptation
- Sources and causes of emergent viruses
 - i. Ecological factors
 - ii. Climate variability
 - iii. Human factors- social behavior
 - iv. Exposure to zoonotic diseases
 - v. Human movement
- Example: one recent example of an outbreak of an emerging virus

6. Anti viral Drugs **3L**

- Screening for Antiviral Compounds
- Designer antivirals and computer-based searching
- Examples of approved drugs and resistance

- Searching for new targets
- Antiviral Gene Therapy

CIA: Test, Model making

References:-

Unit 1

1. Basic Virology, Wagner E, K, Hewlett, M.J, Bloom, D.C., Camerini, D, 3rd ed., 2008, Blackwell Publishing.
2. Freifelder's Essentials of Molecular Biology, 4th ed., 2015, Malacinski GM
3. Microbial Genetics, Maloy, S.R.; Cronan, J.E.; Freifelder, David; 2nd ed., 1994, Jones and Bartlett Publishers.
4. Microbiology – Davis, B.D, Dulbecco, R, Eisen, H.N., and Ginsberg, H.S., 4th ed., 1990, Lippincott, Philadelphia
5. Molecular Biology, Freifelder, D.; 2nd ed., 1987, Narosa Publishing H.
6. The Biology of Viruses, Voyles B. A., 2nd ed., 2002, McGraw-Hill higher education.

Unit 2

1. Comparative Plant Virology, Hull, R., 2nd ed., 2013, Academic Press.

Unit 3

1. Basic Virology, Wagner E, K; Hewlett, M.J, Bloom, D.C., Camerini, D, 3rd ed., 2008, Blackwell Publishing.
2. Principles of Virology, Flint,S.J.; Enquist, L.M.; Racaniello, V.R; and Skalka, A.M. 3rd ed., 2009, Vol I and II, ASM.
3. Understanding Viruses –Shors, T., 3rd ed., 2017, Jones and Bartlett Publishers.

Unit 4

1. Basic Virology, Wagner E, K, Hewlett, M.J, Bloom, D.C., Camerini, D, 3rd ed., 2008, Blackwell Publishing.
2. Principles of Virology - Flint,S.J., Enquist, L.M.; Racaniello V.R; and Skalka, A.M. 3rd ed., 2009, Vol I and II, ASM.
3. Understanding Viruses - Shors,T., 3rd ed., 2017, Jones and Bartlett Publishers.

Title: GENETICS

Course: SMIC0702

LEARNING OBJECTIVES

1. Understand concepts involved in recombination, mutations, repair and regulation of gene expression in bacteria and eukaryotes
2. Understand concepts of cytoplasmic inheritance and transposable elements in eukaryotes
3. Understand viral genetics and study applications based on gene transfer
4. Study the genetic basis of cancer

Number of lectures: 60

UNIT 1: GENE EXPRESSION AND ITS REGULATION

15 LECTURES

LEARNING OBJECTIVES

Understand gene expression and its regulation in prokaryotes and eukaryotes

A. GENE EXPRESSION IN EUKARYOTES

5L

1. Transcription

- Transcription process
- Post transcriptional processing- structure of mRNA, pre-mRNA processing, addition of 5' cap, addition of Poly (A) tail, RNA splicing, RNA editing.
- Small RNA molecules- RNA interference, types, processing and function of microRNAs

2. Translation

- Mechanism of translation, mRNA surveillance.
- Post translational modification of proteins

B. REGULATION OF GENE EXPRESSION

10L

1. Control of gene expression in prokaryotes

- Genes and regulatory element
- Levels of gene regulation
- DNA binding proteins
- Operons
- Antisense RNA molecules
- Riboswitches

2. Control of gene expression in eukaryotes

- Regulation through modification of gene structure- DNase I hypersensitivity, histone modifications, chromatin remodeling, DNA methylation.
- Regulation through transcriptional activators, Co-activators and repressors, enhancers and insulators
- Regulation through RNA processing and degradation
- Regulation through RNA interference

UNIT 2: RECOMBINATION, MUTATION AND DNA REPAIR

15 LECTURES

LEARNING OBJECTIVES

1. Understand the significance of homologous recombination in bacteria and eukaryotes
2. Understand the molecular basis of mutations and DNA repair mechanisms in prokaryotes and eukaryotes

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|--|-----------|
| 1. Recombination | 4L |
| <ul style="list-style-type: none">• Homologous recombination in eukaryotes• Mating type switching | |
| 2. Mutations | 5L |
| <ul style="list-style-type: none">• Molecular basis of mutation - Types, mutations induced by chemicals, radiation and transposable genetic elements; expanding trinucleotide repeats and inherited human diseases | |
| 3. DNA repair mechanisms | 6L |
| <ul style="list-style-type: none">• Excision repair in eukaryotic cells• Mismatch repair in eukaryotic cells• Recombination repair in eukaryotic cells• Conserved repair systems in eukaryotic cells• Non-homologous end joining (NHEJ) pathway for repairing double-stranded breaks• Inherited human diseases with defects in DNA repair | |

UNIT 3: CYTOPLASMIC INHERITANCE and TRANSPOSABLE GENETIC ELEMENTS

15 LECTURES

LEARNING OBJECTIVES

1. Understand cytoplasmic inheritance
2. Understand the mechanisms of chromosomal rearrangements and its effects on gene expression

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|--|-----------|
| 1. Cytoplasmic inheritance | 8L |
| <ul style="list-style-type: none">• Mitochondrial DNA-
Genome structure, replication, transcription and translation, analysis for the study of evolutionary relationships• Chloroplast DNA -
Gene structure and organization, replication, transcription, and translation• Comparison of nuclear, eukaryotic, eubacterial mitochondrial and chloroplast DNA• Examples of extranuclear inheritance | |

- i. Poky mutant of *Neurospora*
- ii. Yeast petite mutant

2. Transposable genetic elements

7L

- Transposable Elements in Eukaryotes
 - i. Ac and Ds Elements in Maize
 - ii. P Elements and Hybrid Dysgenesis in *Drosophila*
 - iii. Mariner, an ancient and widespread Transposon
- Retrotransposons
 - i. Retrovirus-like elements
 - ii. Retroposons
- The Genetic and Evolutionary Significance of Transposable Elements
 - i. Transposons and Genome Organization
 - ii. Transposons and Mutation
 - iii. Rearrangement of Immunoglobulin Genes
 - iv. Evolutionary Issues Concerning Transposable Elements

UNIT 4: VIRAL GENETICS AND GENETICS OF CANCER

15 LECTURES

LEARNING OBJECTIVES

1. Understand the significance of recombination and mapping of the bacteriophage genome
2. Study of the application and analysis based on concepts of gene transfer
3. Understand the genetic basis of cancer

1. Viral genetics

5L

- Mapping the Bacteriophage genome
 - i. Genetic fine structure mapping
 - ii. Deletion mapping
- Overlapping genes: Bacteriophage Φ X174
- Constructing phage vectors- phage display vectors, suicide vectors, combining phage vectors and transposons

2. Genetic basis of cancer

10L

- Cancer: A Genetic Disease
 - i. Forms of Cancer
 - ii. Cancer and the Cell Cycle
- Oncogenes
 - i. Tumor-inducing retroviruses and viral oncogenes
 - ii. Proto-oncogenes
 - iii. Chromosome rearrangement and cancer
- Tumor Suppressor Genes
 - i. Inherited cancers and Knudson's two-hit hypothesis
 - ii. Cellular roles of tumor suppressor proteins
- Genetic Pathways to Cancer

CIA: Open book test, Test

References: -

Unit 1

1. Genetics: A Conceptual Approach, Benjamin Pierce, 6th ed., 2016, W. H. Freeman and Co.
2. Molecular Biology, R. F. Weaver, 5th ed., 2011 McGraw-Hill
3. Molecular Cell Biology - Lodish, H; Berk, A.; Kaiser, C.A. Krieger, M.; Scott, M.; Bretscher, A; Ploegh, H.; and Matsudaira, P; 6th ed., W.H Freeman and Company
4. Molecular Cell Biology, 8th ed., 2016, Lodish et al
5. Molecular Biology of the Gene, Watson, Baker, Bell, Gann, Levine, Losick, 5th edition, 2007, Pearson Education
6. Molecular Biology of the Gene, Watson, Baker, Bell, Gann, Levine, 7th ed., 2013, Benjamin-Cummings Pub Co

Unit 2

1. Genes IX, Lewin B., 2006, Jones and Bartlett Publishers
2. Genes X, Lewin B., 2008, Jones and Bartlett Publishers
3. Genes XII, Lewin B., 2018
4. Molecular Biology of the Gene, Watson, Baker, Bell, Gann, Levine, 7th ed., 2013, Benjamin-Cummings Pub Co
5. Principles of Genetics, Snustad and Simmons, 6th ed., 2012, John Wiley and Sons Inc

Unit 3

1. Fundamental Bacterial Genetics, Turn, Trempy, 1st ed., 2004, Blackwell Publishing
2. Genes X, Lewin, B., 2008, Jones and Bartlett Publishers
3. Genetics: A Conceptual Approach, Benjamin Pierce 5th ed., 2013, W. H. Freeman and Co
4. iGenetics- A Molecular Approach, Russell, P.J., 3rd ed., 2010, Pearson International edition
5. Molecular Biology of the Gene, Watson, Baker, Bell, Gann, Levine, Losick, 5th ed., 2007, Pearson Education

Unit 4

1. Concepts of Genetics, Klug, Cummings, Spencer, Palladino 11th ed., 2016, Pearson Education Ltd
2. Concepts of Genetics, Klug, Cummings, Spencer, Palladino, Killian 12th ed., 2018, Pearson Education Ltd
3. Genetics: A Conceptual Approach, Benjamin Pierce 6th ed., 2017, W. H. Freeman and Co
4. iGenetics, A Molecular Approach, Russell, P.J., 3rd ed., 2010, Pearson International Edition

5. Molecular Biology, R. F. Weaver, 5th ed., 2011 McGraw-Hill
6. Molecular Biology of the Cell, Alberts, B.; Johnson, A.; Lewis, J.; Raff, M.; Roberts K. and Walter P.; 5th ed., 2008, Garland Science, Taylor and Francis Group
7. Molecular Biology of the Cell, Alberts, B.; Johnson, A.; Lewis, J.; Raff, M.; Roberts K. and Walter P.; 6th ed., 2014, Garland Science, Taylor and Francis Group
8. Principles of Genetics, Snustad and Simmons, 6th ed., 2012, John Wiley and Sons Inc
9. The Biology of Cancer, Weinberg, R., 2nd ed., 2013, Garland science.

Title: MICROBIAL BIOCHEMISTRY I

Course: SMIC0703

LEARNING OBJECTIVES

1. Understand the molecular details of bioorganic molecules
2. Understand protein structure, folding and structural bioinformatics
3. Understand bacterial photosynthesis, nitrogen fixation and extracellular transport
4. Understand signalling systems and stress responses in bacteria

Number of lectures: 60

UNIT 1: BIOMOLECULES

15 LECTURES

LEARNING OBJECTIVES

1. Understand the structure and function of carbohydrates and lipids.
 2. Understand the structural details of nucleic acids and factors involved.
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1. Carbohydrates

5L

- Carbohydrates and stability of the glycosidic bond
- Glycoconjugates, proteoglycans, glycoproteins, and glycolipids
- Homopolysaccharide folding
- Functions of oligosaccharides and polysaccharides

2. Lipids

5L

- Lipid classification
- Structure of lipids in membranes- glycerolipids, ether lipids, galactolipids, sulfolipids, lipids in archaeobacteria
- Sphingolipids, terpenes, isoprenoids
- Functions of lipids-signals, cofactors, pigments

3. Nucleic Acids

5L

- The factors that determine the structure of DNA- denaturation and melting curve, Hydrogen bonds and hydrophobic interactions, Base stacking, Ionic strength.
- Renaturation Kinetics - C₀t curve analysis.
- Forms of DNA and circular superhelical DNA.
- Special base sequences and Structural consequences- direct and inverted repeats
- Cruciform, hairpin and stem-loop structures.

UNIT 2: AMINO ACIDS AND PROTEINS

15 LECTURES

LEARNING OBJECTIVES

1. Understand the structures and functions of amino acids and proteins.
 2. Understand protein folding and misfolding.
 3. Understand structural bioinformatics.
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1. Amino acids and primary structure of Proteins

4L

- Classification and stereochemistry
- Derivative and ionization
- Structure of peptide bond and its stability
- Protein sequencing

2. Secondary, Tertiary and Quaternary Structure of Proteins **9L**

- Ramachandran plot
- Secondary structures- α helix and other helices, β structures, non-repetitive structures
- Example fibrous protein: Collagen
- Tertiary structure- Globular proteins
- super secondary motifs
- Thermodynamics of folding and protein stability- Electrostatic forces, Van der Waals forces, Hydrogen bonding forces, Disulfide bonds, Protein Denaturation and stability of the thermostable protein.
- Chaperonins and prion motifs and domains
- Quaternary Structure- subunit interactions and symmetry in protein

3. Structural Bioinformatics **2L**

- Protein databases- NCBI, Swiss-Prot (ExPasy) PDB, PIR
- Protein Structure visualization- SPDBV, Jmol, Rasmol
- Structural Classification- CATH, SCOP, Pfam, CE and VAST.

**UNIT 3: EXPORT SYSTEMS, PHOTOSYNTHESIS AND NITROGEN FIXATION
IN BACTERIA** **15 LECTURES**

LEARNING OBJECTIVES

1. Understand cellular export systems
2. Understand bacterial photosynthesis.
3. Understand biological nitrogen fixation.

1. Cellular export systems **5L**

- Extracellular protein secretion
- Drug export system

2. Bacterial Photosynthesis **5L**

- Phototropic bacterial families
- Photosynthetic Apparatus and its Reactions
- Carbon metabolism

3. Biological Nitrogen Fixation **5L**

- Nitrogen Fixing organisms
- Biochemistry of nitrogen fixation
- Regulation of nitrogen fixation

UNIT 4: SIGNAL TRANSDUCTION IN BACTERIA

15 LECTURES

LEARNING OBJECTIVES

1. Understand signalling systems in bacteria in response to physical and chemical factors
2. Understand bacterial development and quorum sensing

1. General themes in bacterial signal transduction- (basic principles) one component signalling, two-component signalling, quorum sensing, global control networks **2L**

2. Mechanisms of signal transduction **13L**

- Response by facultative anaerobes to
 - i. Anaerobiosis
 - ii. Nitrate and nitrite
 - iii. Nitrogen supply
- Effect of oxygen and light on the expression of photosynthetic genes in purple photosynthetic bacteria
- Response to osmotic pressure
- Chemotaxis
- Bacterial response to environmental stress
 - i. Heat-shock response
 - ii. Oxidative stress
 - iii. Expression of virulence genes/factors
- Quorum sensing
- *Caulobacter* differentiation

CIA: Test, Problem-solving

References: -

Unit 1

1. Biochemistry, Voet D. and Voet J.G., 4th ed., 1995, John Willey and Sons Inc.
2. Lehninger Principles of Biochemistry, Nelson DL, Cox MM, 6th ed., 2013, Macmillan publishers
3. Lehninger Principles of Biochemistry, Nelson DL, Cox MM, 7th ed., 2017, W H Freeman
4. Principles of Biochemistry, Zubay, G., 4th ed., 1998, Wm. C. Brown Publishers
5. Principles Biochemistry, Mathew, Van Holde and Ahern, 3rd ed., 1999, Pearson Education

Unit 2

1. Biochemistry, Voet D. and Voet J.G., 4th ed., 1995, John Willey and Sons Inc.
2. Lehninger Principles of Biochemistry, Cox and Nelson, 7th ed., 2017, WH Freeman and company, NY.

Unit 3

1. Bacterial Metabolism, Gottschalk, G., 2nd ed., 1985, Springer-Verlag

2. Biochemistry, Voet D. and Voet J.G., 4th ed., 1995, John Willey and Sons Inc.
3. Brock Biology of Microorganisms, Michael Madigan, John Martinko, Kelly Bender, Daniel Buckley, David Stahl, 14th ed., 2015, Pearson
4. The physiology and biochemistry of prokaryotes, White D., Drummond, T. J., and Fuqua C., 4th ed., 2007, Oxford University Press

Unit 4

1. Brock Biology of Microorganisms, Michael Madigan, John Martinko, Kelly Bender, Daniel Buckley, David Stahl, 14th ed., 2015, Pearson
2. The Physiology and Biochemistry of prokaryotes, White D., Drummond, T. J., and Fuqua C., 4th ed., 2007, Oxford University Press

Title: IMMUNOLOGY

Course: SMIC0704

LEARNING OBJECTIVES

1. Understand maturation and activation of T/B cells
2. Understand immune response to infectious agents and in turn the immune evasion mediated by these agents
3. Know advances in innate immunity, immune tolerance, autoimmunity, vaccine, transplantation immunology, immunodeficiency diseases and cancer immunology

Number of lectures: 60

UNIT 1: T/B CELL DEVELOPMENT, MATURATION AND ACTIVATION

15 LECTURES

LEARNING OBJECTIVES

1. Understand the maturation, activation and memory generation for T and B cells.
2. Understand the concept of Immune tolerance.

1. T/B cell development

8L

- Site of development
- Lineage Commitment
- Mechanisms of generation of TCR/BCR diversity
- Central and Peripheral Tolerance
- T_{reg} Cells

2. T/B cell activation and memory generation

5L

- T/B cell activation and differentiation
- T/B cell memory generation

3. Use of Fluorescence-activated cell sorting in development and activation of lymphocytes

2L

UNIT 2: ADVANCES IN INNATE IMMUNITY AND IMMUNE RESPONSE TO INFECTIOUS DISEASES

15 LECTURES

LEARNING OBJECTIVES

1. Know advances in innate immunity
2. Know the immune response to prion, viral, bacterial and parasite infections
3. Understand the microbial mechanisms of evading the immune system

1. Recent advances in Non-specific immunity

9L

- Physiological and immunological barriers.
- Induced Cellular Innate Responses
 - i. TLRs
 - ii. NLRs
 - iii. CLR
 - iv. Antimicrobial Peptides
 - v. Interferon
 - vi. Cytokines

- Phagocytosis
- Inflammation
- Interaction between Innate and Adaptive Immune system
- Autophagy

2. Immune response to Infectious agents **4L**

- Prions
- Viruses
- Bacteria
- Parasites

3. Microbial mechanisms of evading the immune system **2L**

UNIT 3: IMMUNE SYSTEM AND HEALTH **15 LECTURES**

LEARNING OBJECTIVES

1. Understand the concept of autoimmunity
2. Know the advances in the fields of vaccines

1. Autoimmunity **5L**

- Interplaying Factors
- Triggering Factors
- Mechanisms of Damage
- Organ Specific Autoimmune Diseases
- Systemic Autoimmune Diseases
- Animal Models for Autoimmune Diseases
- Proposed Mechanisms for Induction of Autoimmunity
- Treatment of Autoimmune Diseases

2. Advances in Immunization **10L**

- Overview
- Passive immunization and Antibody engineering
- Active Immunization
 - i. Malaria vaccine
 - ii. HIV vaccine
 - iii. Pertussis vaccine
 - iv. HPV vaccine
 - v. Tuberculosis vaccine

UNIT 4: CHALLENGES IN IMMUNOLOGY

15 LECTURES

LEARNING OBJECTIVES

Know the advances in the fields of transplantation immunology, immunodeficiency diseases and cancer immunology

1. Transplantation and Transfusion Immunology 5L

- Antigen Involved in Graft Rejection
- Allorecognition
- Graft Rejection-Role of APCs and Effector Cells
- Graft v/s Host Diseases
- Immunosuppressive Therapies
- Blood Transfusion
 - i. ABO and Rh Blood Groups (revision)
 - ii. Potential Transfusion Hazards
 - iii. Transfusion Alternatives

2. Immunodeficiency diseases 5L

- Primary Immunodeficiency
- Defects in the Complement System
- Treatment Approaches for Immunodeficiency
- Animal Models of Primary Immunodeficiency
- Secondary Immunodeficiency and AIDS

3. Cancer immunology 5L

- The Immune Response to Cancer
- Cancer Immunotherapy

CIA: Test, Presentation

References:-

Unit 1

1. Immunology – Essential and Fundamental, Pathak, S. and Palan, U., 3rd ed., 2011, Capital publishing company.
2. Janeway's Immunobiology - The immune system in health and disease, Murphy, M. K., Travers, P., Walport, M. and Janeway, C., 9th ed., 2017, Garland Science, 2011
3. The Immune Response to Infection, Kauffman, S. H. E., Rouse B.T., and Sacks D.L., 2011, ASM Press, Washington, USA
4. Kuby Immunology, Kindt, J. T., Osborne, A. B. and Goldsby, A. R., 6th ed., 2006, W.H. Freeman and company.
5. Kuby Immunology, Owen, J., Punt, J. and Stanford, S., 7th ed., 2013, International Edition, Macmillan Higher Education.
6. Mims' Pathogenesis of Infectious Disease, Mims, A. C., Nash, A. and Stephen, J., 5th ed., 2000, Academic Press.

7. Mims' Pathogenesis of Infectious Disease, Mims et al., 6th ed., 2015, Academic Press.
8. Current published papers/ reviews

Unit 2

1. Janeway's Immunobiology –the immune system in health and disease, Murphy, M. K., Travers, P., Walport, M. and Janeway, C., 6th ed., 2011, Garland Science.
2. The Immune Response to Infection, Kauffman, S. H. E., Rouse B.T., and Sacks D.L., 2011, ASM Press, Washington, US
3. Kuby Immunology, Kindt, J. T., Osborne, A. B. and Goldsby, A. R., 6th ed., 2006, W. H. Freeman and company.
4. Kuby Immunology, Owen, J., Punt, J. and Stanford, S., 7th ed., 2013, International Edition, Macmillan higher education.
5. Takeuchi, O. and Akira, S., Pattern recognition receptors and inflammation, 2010, Cell, 140: 805-820
6. Current published papers/ reviews

Unit 3

1. Arama, C. and Troye-Blomberg, M., The path of malaria vaccine development: challenges and perspectives, The journal of internal medicine, 2014, doi: 10.1111/joim.12223
2. Chen, Y.Z. and Dolin R., Novel HIV vaccine strategies: overview and perspective, 2013, Therapeutic Advances in Vaccines, (0)0-1-14
3. Kim, K.S., Park, S.A., Ko, K., Yi, S., Cho, Y.J., Current status of human papillomavirus vaccines, 2014, Clin Exp Vaccine Res;3:168-175
4. Kuby Immunology, Kindt, J. T., Osborne, A. B. and Goldsby, A. R., 6th ed., 2006, W. H. Freeman and company.
5. Kuby Immunology, Owen, J., Punt, J. and Stanford, S., 7th ed., 2013, International Edition, Macmillan higher education.
6. Rosalind Rowland1 and Helen McShane, Tuberculosis vaccines in clinical trials, Expert Rev Vaccines, 2011 May; 10(5): 645–658
7. Current published papers/ reviews

Unit 4

1. Kuby Immunology, Kindt, J. T., Osborne, A. B. and Goldsby, A. R., 6th ed., 2006, W. H. Freeman and company.
2. Kuby Immunology, Owen, J., Punt, J. and Stanford, S., 7th ed., 2013, International Edition, Macmillan higher education.
3. Roitt's Essential Immunology, Delves, J. P., Martin, J. S., Burton, R. D. and Roitt, . I., 12th ed., 2011, John Wiley and Sons.
4. Roitt's Essential Immunology, Delves et al, 13th ed., 2017
5. Current published papers/ reviews

MICROBIOLOGY

SMIC07PR

Semester 1 practical

LABORATORY SKILLS

1. Lab safety –
 - Hand washing and hygiene
 - Effectiveness of disinfectants
 - Burner versus Biosafety cabinet
 - How to dispose off ethidium bromide, blood products, media components
 - Safety in handling chemicals (eg: acrylamide, ethidium bromide)
 - PPE
2. The principle of lab instruments, care, and handling.
 - Autoclave, hot air oven, incubator
 - Shaker, centrifuge, microscopes,
 - Biosafety cabinets, colorimeter, automated pipettes
3. Preparation of solutions and lab media
 - Molarity and Normality
 - Liquid and solid media, with and without indicators
 - Media with components to be separately sterilized, such as antibiotics
 - Preparation of slants, butts, and plates
4. Preparation of buffers
5. Determination of pK and pI value for an amino acid
6. Sterilization of heat sensitive material, Sterility check - Efficiency of sterilization
7. Sub-culturing, lyophilization, glycerol-stock preparation
8. Industrial visit

SCIENTIFIC COMMUNICATION SKILLS

Referencing, Oral and poster presentation, Concept of plagiarism, summary writing

GENETICS

1. UV mutagenesis
2. Acridine orange mutagenesis
3. Penicillin enrichment technique and mutant isolation by replica plating (grid plate)
4. Ames test
5. Conjugation in bacteria
6. Problems on gene transfer mechanisms

VIROLOGY

1. Isolation and purification of coliphages from sewage
2. Study of One Step Growth Curve of Lambda phage / T4 Phage.
3. Isolation of host range mutants
4. Egg inoculation and cultivating animal virus in embryonated egg - Demonstration
5. Problems on viral genetics

MICROBIAL BIOCHEMISTRY

1. Isolation of cholesterol and lecithin from egg yolk
2. Identification of fatty acids and other lipids by TLC/GC
3. Determination of degree of unsaturation of fats and oils
4. Identification of an unknown carbohydrate
5. Isolation of lactose from bovine milk
6. Estimation of total sugars by the phenol-sulphuric acid method
7. Isolation of glutamic acid from gluten
8. Determination of molar absorption coefficient (ϵ) of l-tyrosine
9. Determination of the isoelectric point of the given protein
10. Estimation of polyphenols/ tannins by Folin- Denis method
11. Diffusion studies of molecules across sheep RBCs
12. Adaptation of *E. coli* to anaerobiosis
13. Chemotaxis of *Pseudomonas*

IMMUNOLOGY

1. Separation of mononuclear cells from blood by Ficoll-Hypaque density gradient centrifugation, counting of viable cells by trypan blue.
2. Staining of blood smear
3. Study of virulence factors-Phagocytosis and Phagocytic index.
4. Horizontal electrophoresis of proteins – Human serum
5. Immunoelectrophoresis
6. Determination of Rh – Antibody titre
7. Major and Minor cross-matching of blood.
8. SRID: For detection of immune deficiency and Complement deficiency.
9. ELISA- qualitative and quantitative

CIA: Experimental, Primary research paper presentation, Instrument maintenance with SOP writing

References:

1. The Biology of Viruses, Voyles B. A., 2nd ed., 2002, McGraw-Hill higher education.
2. Medical Microbiology, Cruickshank R., 11th ed., 1965, E and S. Livingston Ltd.
3. Biosafety manual of the college
4. Textbook of Microbiology –Ananthnarayan and Paniker-10th ed.,2017, University Press
5. Microbial Genetics, Maloy, S.R.; Cronan, J.E.; Freifelder, David 2nd ed., 1994, Jones and Bartlett Publishers.
6. Molecular Cloning: A Laboratory Manual (3 Volume Set), J. Sambrook, E. F. Fritsch, T. Maniatis, 2nd ed., 1989, Cold Spring Harbor Laboratory Pr.
7. Microbiology, Davis, B.D; Dulbecco, R; Eisen, H.N. and Ginsberg,H.S.; 3rd ed., 1980 Harper International ed. NY.
8. Principles of Genetics, Snustad and Simmons, 6th ed., 2012, John Wiley and Sons Inc

9. Genetics: A Conceptual Approach, Benjamin Pierce 3rd ed., 2008, W. H. Freeman and Co
10. Genetics: A Conceptual Approach, Benjamin Pierce 5th ed., 2013
11. iGenetics- A Molecular Approach, Russell, P.J., 3rd ed., 2010, Pearson International ed.
12. Laboratory manual in biochemistry by Jayaraman J., 1981, New Age International Publishers
13. An introduction to practical biochemistry 3rd ed., 1998, David T Plummer, Tata McGraw Hill ed.
14. Experimental biochemistry –A student companion, B Sashidhar Rao, Vijay Deshpande, S. Deshpande, 2005, IK international Pvt. Ltd..
15. Microbial Physiology and Biochemistry Laboratory manual: A quantitative approach, David White, 1998
16. Principles and techniques of practical biochemistry, 4th ed. (1998), Wilson K. and Walker J.(Ed.) Cambridge University Press, 1994
17. Principles and Techniques of Biochemistry and Molecular Biology, Wilson K and Walker J, 7th ed., 2011
18. Biochemical calculations, Segel I.R., 2nd ed., 2004, John Wiley and Sons
19. Textbook of Medical laboratory technology- by P B Godkar,1994, Bhalani Publishing House



St. Xavier's College (Autonomous) Mumbai

M.Sc. Syllabus For 2nd Semester Courses in **Microbiology** (June 2018 onwards)

Contents:

Theory Syllabus for Courses:

**SMIC0801 - CELL BIOLOGY: STRUCTURE, TRANSPORT, AND
JUNCTIONS**

SMIC0802 - GENETICS AND BIOINFORMATICS

SMIC0803 - MICROBIAL BIOCHEMISTRY II

SMIC0804 - RESEARCH METHODOLOGY AND BIOSTATISTICS

SMIC08PR: Practical Syllabus for Courses:

CELL BIOLOGY AND BIOINFORMATICS

MOLECULAR BIOLOGY

MICROBIAL BIOCHEMISTRY

**RESEARCH METHODOLOGY, BIOSTATISTICS AND
MATHEMATICS**

Title: CELL BIOLOGY: STRUCTURE, TRANSPORT, AND JUNCTIONS
Course: SMIC0801

LEARNING OBJECTIVES

1. Understand the origin of cellular life and basic cell structure.
2. Understand the structure and function of the cell membrane
3. Understand the protein transport within cells
4. Understand the role of cellular structures involved in cytoskeleton and cell junctions.

Number of lectures: 60

UNIT 1: ORIGIN OF CELLULAR LIFE AND BASICS OF CELL BIOLOGY
15 LECTURES

LEARNING OBJECTIVES

1. Understand the origin of organic molecules, prokaryotic and eukaryotic cells
2. Understand the structure of cells and cell organelles.
3. Understand the use of microscopy in cell biology

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- | | |
|---|-----------|
| 1. Origin of cellular life | 5L |
| <ul style="list-style-type: none">• Origin of basic biological molecules; abiotic synthesis of organic monomers and polymers• The first cell; evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes. | |
| 2. Overview of cell and cell organelles | 5L |
| 3. Cell study - microscopy | 5L |
| <ul style="list-style-type: none">• Confocal microscopy• Electron microscopy.• Atomic force microscopy• TIRF microscopy | |

UNIT 2: MEMBRANE STRUCTURE AND TRANSPORT **15 LECTURES**

LEARNING OBJECTIVES

1. Understand the structure of the Cell membrane
2. Understand the transport function of the membrane

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- | | |
|--|-----------|
| 1. Cell membrane structure | 7L |
| <ul style="list-style-type: none">• Lipid bilayer• Membrane proteins• RBC membrane as an example of membrane | |

- Multipass membrane proteins
- Bacteriorhodopsin

2. Membrane Transport **8L**

- Principles of membrane transport
- Transporters and Active Membrane Transport
- Ion channels
- Electrical properties of membranes with examples.

UNIT 3: INTRACELLULAR TRAFFIC **15 LECTURES**

LEARNING OBJECTIVES

Understand protein sorting and trafficking in cells

1. Intracellular Compartments and protein sorting **9L**

- Compartmentalization of cells
- Transport of molecules between the nucleus and cytosol
- Transport of proteins into mitochondria and chloroplasts
- Peroxisomes
- Endoplasmic reticulum

2. Intracellular vesicular traffic **6L**

- Endocytosis
- Exocytosis
- Transport from the ER through the Golgi apparatus

UNIT 4: CYTOSKELETON AND CELL JUNCTIONS **15 LECTURES**

LEARNING OBJECTIVES

1. Understand the structure and function of the cytoskeletal filaments
2. Study aspects of cell junctions and cell adhesion

1. Cytoskeleton **8L**

- Cytoskeletal filaments
- Microtubules
- Microfilaments, Actin regulation
- Intermediate filaments
- Molecular motors
- Cell behavior

2. Cell Junctions and Cell adhesion **7L**

- Extracellular matrix (ECM): components and ECM examples - Basal lamina and connective tissue ECM

- Types of cell-ECM junctions
 - i. Focal adhesions
 - ii. Hemidesmosomes
- Types of cell-cell junction
 - i. Adherens junction
 - ii. Desmosomes
 - iii. Tight junction
 - iv. Gap junction
- Cell-cell junctions in plants - plasmodesmata

CIA: Test, Assignment

References:-

Unit 1 to 4

1. Cell biology, Gerald Karp, 6th ed., 2010, Wiley
2. Molecular Biology of the Cell – Alberts, B.; Johnson, A.; Lewis, J.; Raff, M.; Roberts K. & Walter P., 6th ed., 2015, Garland Science, Taylor & Francis Group
3. The Cell: A Molecular Approach, Cooper, G., Hausman, R., 5th ed., 2009, ASM Press

Title: GENETICS AND BIOINFORMATICS

Course: SMIC0802

LEARNING OBJECTIVES

1. Understand the tools available for molecular biology
2. Understand the concepts of population genetics
3. Understand the applications of genetic technology and the ethics involved
4. Understand the use of bioinformatics for biological data analysis

Number of lectures: 60

UNIT 1: MOLECULAR TOOLS FOR GENETICS

15 LECTURES

LEARNING OBJECTIVES

Understand the significance of molecular tools used in recombinant DNA techniques

1. Molecular tools for genetics

9L

- Labeled tracers (autoradiography, phosphorimaging, liquid scintillation counting, non-radioactive tracers)
- Overview of Nucleic acid hybridization, *In situ* hybridization, DNA sequencing, Restriction mapping
- Mapping and quantifying transcripts (S1 mapping, primer extension, run-off transcription)
- Measuring transcription rates *in vivo* (nuclear run-on transcription, reporter gene transcription), Assaying DNA-protein interactions (filter binding, gel mobility shift, DNase and DMS footprinting, knockouts)
- Aptamers: molecular tools for analytical applications

2. Rational Mutagenesis

4L

- Oligonucleotide-directed mutagenesis - with M13
- Oligonucleotide-directed mutagenesis - with plasmid DNA
- PCR amplified oligonucleotide-directed mutagenesis
- Random mutagenesis - with a degenerate oligonucleotide primer
- Random mutagenesis - with nucleotide analogues
- Error-prone PCR
- DNA shuffling
- Mutant proteins with unusual amino acids

3. Modifications of PCR

2L

- PCR
Hot- Start, Multiplex, Nested, RT-PCR, Broad Range, arbitrarily primed, Quantitative, Real-time

UNIT 2: POPULATION GENETICS

15 LECTURES

LEARNING OBJECTIVES

1. Understand the concepts involved in population genetics and epigenetics
2. Learn the application and analysis based on concepts of population genetics

1. Population genetics

7L

- Population and gene pool
- Genotypic and allelic frequencies
- Calculation of genotypic frequencies and allelic frequencies for autosomal and X linked loci
- Problems - calculation of allelic and genotypic frequencies
- Hardy-Weinberg Law, genotypic frequencies at HWE
- Implications of the H-W Law
- H-W proportions for multiple alleles
- X-linked alleles
- Testing for H-W proportions and problems
- Genetic ill effects of in-breeding
- Changes in the genetic structure of populations
 - i. Mutation
 - ii. Migration and gene flow
 - iii. Genetic drift
 - iv. Natural selection
 - v. Simple problems based on the natural forces

2. Epigenetics

8L

- The Nucleosome: Chromatin's structural unit
- Higher order chromatin structure
- Histone: Modifications and epigenetic information
- Chromatin remodelling
- Silencing of gene expression
- Genomic imprinting, Dosage compensation

UNIT 3: APPLICATIONS AND ETHICS OF GENETIC TECHNOLOGY

15 LECTURES

LEARNING OBJECTIVES:

1. Understand molecular mapping of human genes
2. Understand diagnosis and therapy of genetic disorders
3. Understand concepts of recombinant DNA technology
4. Understand the ethical issues concerning the use of recombinant DNA technology

1. Mapping Human Genes at the Molecular Level

2L

- RFLPs as genetic markers
- Linkage analysis using RFLP - Huntington's diseases, Cystic fibrosis

- Positional Cloning: The gene for neurofibromatosis
- The Candidate Gene Approach: The gene for Marfan Syndrome
- Fluorescent in Situ Hybridization (FISH) gene mapping

2. Genetic Disorders: Diagnosis and Screening **3L**

- Prenatal genotyping for mutations in the β -globin gene
- Prenatal diagnosis of sickle-cell anemia
- Single nucleotide polymorphisms and genetic screening
- DNA microarrays and genetic screening

3. Treating Disorders with Gene Therapy **4L**

- Gene therapy for Severe Combined Immunodeficiency (SCID) - Overview
- Problems and failures in gene therapy
- The future of gene therapy: new vectors and target-cell strategies
- Ethical issues of gene therapy

4. DNA Fingerprints **2L**

- Minisatellites (VNTRs) and microsatellites (STRs)
- Forensic applications of DNA fingerprints

5. The Human Genome Project **2L**

- An overview
- The Ethical, Legal, and Social Implications (ELSI) Program

6. Pharmacogenetics and toxicogenomics **2L**

UNIT 4: BIOINFORMATICS

15 LECTURES

LEARNING OBJECTIVES

1. Understand and access various types of data relating to molecular biology available on internet portal
2. Understand the concept of sequence alignment of biological macromolecules

1. Study of biological databases with examples **3L**

- Types of databases
 - i. Primary
 - ii. Secondary
 - iii. Sequence
 - iv. Structure
 - v. Metabolic (KEGG)
- Biological data retrieval
- Study of data formats

2. Nucleotide sequence analysis **6L**

- Pairwise alignment and scoring matrices
- Multiple sequence alignment
- Phylogenetic analysis
- Sequence logo (WebLogo) and consensus sequences
- Analysis of plasmids and other vectors using a software

3. Protein analysis **4L**

- Using 3D structure viewers (Rasmol, PDB)
- CATH and SCOP classification

4. Reference management software **2L**

- Making a reference library
- Adding references from the library into a word document

CIA: Test, Assignment

References:

Unit 1:

1. Concepts of Genetics, Klug, Cummings, Spencer, Palladino 11th ed., 2016, Pearson Education Ltd
2. Genetics: A Conceptual Approach, Benjamin Pierce 6th ed. , 2017, W. H. Freeman & Co
3. Molecular Biology, R. F. Weaver, 5th ed., 2011 McGraw-Hill
4. Molecular Biotechnology: Principles and Applications of Recombinant DNA, Bernard R. Glick, Jack J. Pasternak, 4th ed., (2010), ASM Press
5. Principals of Genetics, Snustad & Simmons, 6th ed., 2012, John Wiley & Sons Inc
6. Recombinant DNA, J.D. Watson, 2nd ed., 1992, Scientific American Books
7. Lakhin, A. V., Tarantul, V. Z., & Gening, L. V. (2013). Aptamers: problems, solutions, and prospects. *Acta Naturae*, 5(4 (19)).
8. Mairal, T., Özalp, V. C., Sánchez, P. L., Mir, M., Katakis, I., & O'Sullivan, C. K. (2008). Aptamers: molecular tools for analytical applications. *Analytical and bioanalytical chemistry*, 390(4), 989-1007.

Unit 2:

1. Chromatin and Gene Regulation Mechanisms in Epigenetics, Bryan M. Turner, 2001 Blackwell Science.
2. iGenetics, A Molecular Approach, Russell, P.J., 3rd ed., 2010, Pearson International Ed.
3. Molecular Biology of the Gene, Watson, Baker, Bell, Gann, Levine, Losick, 5th ed., 2007, Pearson Education
4. Molecular Biology of the Gene, Watson, Baker, Bell, Gann, Levine, 7th ed., 2013, Pearson Education
5. The Concept of Genetics, William S. Klug & Michael R. Cummings, 7th ed., 2007, Pearson Education

Unit 3:

1. iGenetics, A Molecular Approach, Russell, P.J., 3rd ed., 2010, Pearson International Ed.
2. Recombinant DNA, J.D. Watson, 2nd ed., 1992, Scientific American Books
3. Concepts of Genetics, Klug, Cummings, Spencer, Palladino 11th ed., 2016, Pearson Education Ltd

Unit 4:

1. Bioinformatics and Functional Genomics, Pevsner J., May 2009, Wiley-Blackwell
2. Essential Bioinformatics, Jin Xiong, 1st ed., 2007, Cambridge University Press
3. Introduction to Bioinformatics, Attwood T.K., Parry-Smith D.J., Phukan Samiron, Pearson Education 2007

Title: MICROBIAL BIOCHEMISTRY II

Course: SMIC0803

LEARNING OBJECTIVES

1. Understand various methods of analytical biochemistry
2. Understand enzyme kinetics, regulation and mechanism of enzyme action
3. Understand the metabolism of one and two carbon compounds
4. Understand the biosynthesis of macromolecules

Number of lectures: 60

UNIT 1: ANALYTICAL BIOCHEMISTRY

15 LECTURES

LEARNING OBJECTIVES

Study the purification techniques and analytical methods for biomolecules

Extraction, purification and analysis of proteins, carbohydrates and lipids 15L

- General methods of extraction
- Purification methods and determination of purity (based on Solubility, Molecular weight, Charge): pH, Salting out, solvent precipitation, molecular exclusion chromatography, PAGE, SDS-PAGE, western blotting, Ion exchange , chromatography, isoelectric focussing, 2-D gel electrophoresis, Affinity chromatography, Dye ligand chromatography
- Qualitative and quantitative analysis of carbohydrates and lipids

UNIT 2: ENZYMOLOGY

15 LECTURES

LEARNING OBJECTIVES

1. Understand the basic aspects of enzyme kinetics
 2. Study the regulation of enzymes with specific examples
 3. Study the catalytical mechanism of action of enzymes.
-

1. Enzyme kinetics

6L

- Kinetics of one substrate reactions
 - i. Equilibrium assumptions
 - ii. Steady state assumptions
 - iii. Lineweaver-Burk, Hanes-Woolf, Eadie-Hofstee equations and plots
- Kinetics of enzyme inhibition.
Competitive, non-competitive and uncompetitive inhibition
- Effect of changes in pH and temperature on enzyme catalysed reaction
- Kinetics of two substrate reactions
- Pre steady state kinetics
- Kinetics of immobilized enzymes
- Problem solving

2. Enzyme catalysis **6L**

- Catalytic mechanisms with type examples, catalytic mechanisms and testing - Serine proteases and Lysozyme
- Problem solving.

3. Enzyme regulation **3L**

- Allosteric enzyme - general properties, Hill, MWC and KNF models.
- Covalent modification by various mechanisms.
- Regulation by proteolytic cleavage - blood coagulation cascade.
- Regulation of multi-enzyme complex- Pyruvate dehydrogenase
- HIV enzyme inhibitors and drug design
- Problem solving

UNIT 3: METABOLISM OF ONE AND TWO CARBON COMPOUNDS

15 LECTURES

LEARNING OBJECTIVES

Understand the metabolism of one and two carbon compounds

1. Metabolism of one carbon compounds **11L**

- **Methylotrophs**
 - i. Oxidation of methane, methanol, methylamines
 - ii. Carbon assimilation in methylotrophic bacteria and yeasts
- **Methanogens**
 - i. Methanogenesis from H₂, CO₂, CH₃OH, HCOOH, methylamines
 - ii. Energy coupling and biosynthesis in methanogenic bacteria
- **Acetogens**
Autotrophic pathway of acetate synthesis and CO₂ fixation
- **Carboxidotrophs**
Biochemistry of chemolithoautotrophic metabolism
- **Cynogens and cynotrophs**
Cynogenesis and cyanide degradation

2. Metabolism of two-carbon compounds **4L**

- **Acetate**
 - i. TCA and Glyoxylate cycle, modified citric acid cycle
 - ii. Carbon monoxide dehydrogenase pathway and disproportionation to methane
- **Ethanol**
Acetic acid bacteria
- **Glyoxylate and glycolate**
 - i. Dicarboxylic acid cycle
 - ii. Glycerate pathway
 - iii. Beta hydroxyaspartate pathway

- **Oxalate as carbon and energy source**

UNIT 4: OVERVIEW OF METABOLISM

15 LECTURES

LEARNING OBJECTIVES

1. Understand the catabolism and anabolism of carbohydrates, amino acids, ribonucleotides and fatty acids
2. Understand the interrelation of metabolic pathways

1. Metabolism of carbohydrates	8L
<ul style="list-style-type: none">• Glycolysis• TCA cycle• Gluconeogenesis• Pentose phosphate pathways• Tracer studies• Metabolic regulation• Metabolic pathway analysis: quantitative aspects	
2. Biosynthesis of ribonucleotides and deoxyribonucleotides	3L
<ul style="list-style-type: none">• The de novo pathway• Regulation by feedback mechanisms• Recycling via the salvage pathway	
3. Amino acid degradation and biosynthesis (revision)	2L
4. Lipid degradation and biosynthesis (revision)	2L

CIA: Tests

References: -

Unit 1

1. Principles of Biochemistry, Horton, R. and Moran, L., 5th ed., 2011, Prentice Hall
2. Principles of Biochemistry, Lehninger A.L., Nelson and Cox, 6th ed., 2000, WH Freeman and company, NY.
3. Principles of Biochemistry, Zubay, G., 4th ed., 1998, Wm.C. Brown Publishers

Unit 2

1. Biochemistry, Berg J.M., Tymoczko J.L. and Stryer L., 7th ed., 2012, W. H. Freeman and co.
2. Biochemistry, Voet D. and Voet J.G., 4th International student ed., 2011, John Wiley and sons.
3. Biochemistry- A Problem Approach, Wood W. B. Wilson J.H., Benbow R.M. and Hood L.E., 2nd ed., 1981, The Benjamin/ Cummings Pub.co.
4. Biochemical calculations, Segel I.R., 2nd ed., 2004, John Wiley and Sons

5. Fundamentals of Enzymology, Price N.C. and Stevens L. 3rd ed.,1999, Oxford University Press.
6. Principles of Biochemistry, Lehninger A.L., Nelson and Cox, 6th ed., 2000, WH Freeman and company, NY.
7. Principles of Biochemistry, Lehninger A.L., Nelson and Cox, 7th ed., 2017, WH Freeman and company, NY.

Unit 3

1. Bacterial metabolism, Gottschalk, G., 2nd ed., 1985, Springer-Verlag
2. Biotechnology: The biological principles, Trevan M. D., Boffey S., Goulding K. H., Stanbury P., 1998, Tata MacGraw-Hill, 8th reprint.
3. The physiology and biochemistry of prokaryotes, White D., Drummond, T. J., and Fuqua C., 4th ed., 2007, Oxford University Press

Unit 4

1. Biochemistry, Voet D. and Voet J.G.,4th International student ed., 2011, John Wiley and Sons.
2. Principles of Biochemistry, Lehninger A.L., Nelson and Cox, 6th ed., 2000, WH Freeman and company, NY.
3. Lehninger Principles of Biochemistry, Nelson DL, Cox MM, 7th ed., 2017, WH Freeman and company, NY.

Title: RESEARCH METHODOLOGY AND BIOSTATS

Course: SMIC0804

LEARNING OBJECTIVES

1. Understand the overall process of designing a research study from its inception to its report.
2. Be able to distinguish between the writing structure used for a quantitative study and one used for a qualitative study.
3. Know the different conventions for scholarly/ report writing

Number of lectures: 60

UNIT 1: RESEARCH FUNDAMENTALS, TERMINOLOGY AND REPORT WRITING **15 LECTURES**

LEARNING OBJECTIVES

1. To know how to identify a research problem
2. Understand importance of educational research
3. Understand basics of research design

1. Meaning and Objective of research **2L**

- Features of a good research study
- Scientific method

2. Study designs and variations **8L**

- Basic, applied, historical, exploratory, experimental, ex-post-facto
- Case study, diagnostic research
- Crossover design, case control design, cohort study design, multifactorial design

3. Report writing and presentation **5L**

- Types of research reports, guidelines for writing a report, report format, appendices
- Miscellaneous information
- Poster and oral presentations (use of software)
- Project proposal

UNIT 2: DEFINING A RESEARCH PROBLEM, DATA COLLECTION AND DATA ANALYSIS **15 LECTURES**

LEARNING OBJECTIVES

1. Understand concepts of quantitative and qualitative data collection
2. Understand how to analyze data

1. Hypothesis, theory and scientific law **2L**

- Difference between hypothesis, theory and scientific law
- Formulation of hypothesis

- 2. Methods and techniques of data collection** **7L**
- Types of data
 - Methods of primary data collection (observation/ experimentation/ questionnaire/ interviewing/ case/ pilot study)
 - Methods of secondary data collection (internal/ external), schedule method
 - Use of computers in data collection- Literature survey using web, handling search engines
- 3. Experimental data collection and data processing** **4L**
- Processing operations, problems in processing
 - Elements of analysis in data processing
- 4. Introduction to design of experiments** **2L**

UNIT 3: BIostatistics: INTRODUCTION AND PARAMETRIC TESTS
15 LECTURES

LEARNING OBJECTIVES

1. Understand sampling, types of data and distribution of data
2. Understand how to conduct a statistical test of a hypothesis.
3. Understand how to apply tests for comparison of one, two or multiple means for normally distributed data

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- 1. Sampling, Sampling Distributions & Sampling Errors** **2L**
- Simple random sampling, systematic sampling, stratified random sampling, cluster sampling
 - Non random sampling
 - Sampling Errors
- 2. Types of data and distribution** **3L**
- Nominal, ordinal, interval and ratio scale
 - Continuous and discrete data
 - Skewness and Kurtosis
 - Normal distribution- Box plot
- 3. Test of Significance** **3L**
- Null Hypothesis, Alternate Hypothesis, Type I & Type II errors
 - Level of Significance, one tailed & two tailed test
 - Concept of Standard error
- 5. Comparison of means of one or two samples** **4L**
- t test
 - z test
 - test for homogeneity of variance

6. Comparison of means of 3 or more samples **3L**

- 1-way ANOVA
- Types of ANOVA

UNIT 4: BIOSTATISTICS: NON- PARAMETRIC TESTS, CORRELATION AND REGRESSION **15LECTURES**

LEARNING OBJECTIVES

1. Understand the application of parametric tests for nominal and ordinal data
2. Understand correlation and regression

1. Non parametric tests for nominal data **4L**

- Chi square test
- Fisher's exact test

2. Non parametric tests for ordinal data **4L**

- Wilcoxon rank-sum test (aka Mann-Whitney U)
- Sign test
- Wilcoxon signed-rank test

3. Non parametric alternatives to ANOVA **2L**

4. Correlation & Regression **5L**

- Types of Correlation
- Degree of Correlation
- Linear Regression Analysis
- Regression Lines & Regression Equations

CIA: Problem Solving- Biostatistics, Test

References:-

Units 1 and 2:

1. Research Methodology - Methods and Techniques, Kothari, C.R., 2004, 2nd ed., New Delhi, New age international publishers.
2. Research Methodology - Bhattacharya, D.K., 2006, 2nd ed., New Delhi, Excel Books.
3. Research Methods in Biosciences, Holmes D., 2006, Oxford University Press
4. Research Methodology: A Handbook, Misra R.P., 1989, New Delhi, Concept Publishing Company
5. Introduction to Biostats and Research Methodology, Sunder Rao P. S. S., 4th ed., 2006, Prentice-Hall Pvt. Ltd.
6. Design and analysis of experiments, D.C. Montgomery, Wiley Student Ed., 8thed., 2009

7. <http://www.cebm.net/wp-content/uploads/2014/06/CEBM-study-design-april-2013.pdf>
8. <http://www.cebm.net/study-designs/>

Unit 3 and 4:

1. Biostatistical Analysis, Czar J. H., 5th ed., 2014, Pearson India education services, India.
2. Biostatistics The Bare Essentials, Norman G.R., Streiner D.L., 3rd ed., 2008, B. C. Decker Inc

MICROBIOLOGY

SMIC08PR

Semester 2 practical

CELL BIOLOGY AND BIOINFORMATICS

1. Mitosis in onion root tip
2. Meiosis in *Tradescantia*
3. Isolation of mitochondria
4. Isolation of chloroplast
5. Study of cell membrane integrity
6. Study of cell cytology using Phase contrast Microscopy. Demonstration
7. Study of Cell structure using Confocal Microscopy. Demonstration
8. Study of Cell structure using Fluorescence Microscopy. Demonstration
9. Understanding PubMed databases
10. Introduction to National Center for Biotechnology Information (NCBI)
11. Analysis of protein sequence from protein databases
12. Analysis of nucleotide sequence from nucleotide databases
13. Similarity search using the BLAST and interpretation of the results
14. Getting the gene sequences by exploring and querying the nucleic acid databases
15. Pair-wise sequence alignment by using BLAST and ClustalW
16. Multiple sequence alignment by using ClustalW
17. Phylogenetic analysis using web tool
18. Tertiary protein structure analysis using Rasmol
19. Understanding of Kyoto Encyclopedia of Genes and Genome (KEGG) database for biological pathways, metabolism, cellular process, genetic information processing

MOLECULAR BIOLOGY

1. Genomic DNA isolation
2. Primer designing
3. PCR
4. Restriction digestion
5. Ligation in a suitable vector for cloning
6. Transformation in bacteria
7. Plasmid isolation
8. Agarose gel electrophoresis at each of the above stages.
9. Isolation of RNA
10. β galactosidase assay
11. Problems on population genetics

BIOCHEMISTRY

1. Purification of an extracellular enzyme (β -amylase) by salting out and dialysis.
2. SDS PAGE to be done at each stage of purification
3. Native PAGE and activity staining to be done at the end of purification step.

4. Enzyme kinetics-effect of enzyme concentration, substrate concentration, pH, temperature and inhibitors on enzyme activity with Amylase.
5. Isolation of Lysozyme from egg white and purification using ion exchange chromatography.
6. Western blot- Demonstration

RESEARCH METHODOLOGY, BIostatISTICS AND MATHEMATICS

1. Writing of a grant proposal
2. Literature survey and reference management tools
3. Use of software in biostatistical analysis
4. Introduction to mathematical modeling
5. Mathematics
 - i. Limits, derivatives and integration
 - ii. Vectors and matrices
 - iii. Basic Algorithms

CIA: Bioinformatics assignment/ Cell biology experiment, Enzymology experiment, Molecular biology technique, Grant proposal writing

References:

1. Bioinformatics and functional genomics, J. Pevsner, 2nd ed., 2009, Wiley-Blackwell publishers
2. Introduction to bioinformatics, T. Attwood, 1st edition, 2001, Benjamin Cummings publishers
3. iGenetics- A Molecular Approach, Russell, P.J., 2010 Third Ed., Pearson International Ed.
4. Concepts of Genetics, Klug, Cummings, Spencer, Palladino 11th ed., 2016, Pearson Education Ltd
5. Concepts of Genetics, Klug, Cummings, Spencer, Palladino, Killian 12th ed., 2018, Pearson Education
6. Genetics: A Conceptual Approach, Benjamin Pierce 6th ed., 2017, W. H. Freeman & Co
7. Genes-X, Lewin, B., 2008, Jones and Bartlett Publishers
8. Molecular Cloning: A Laboratory Manual (3 Volume Set), J. Sambrook, E. F. Fritsch, T. Maniatis, 2nd ed., 1989, Cold Spring Harbor Laboratory Pr.
9. Principles and techniques of practical biochemistry, 4th ed. (1998), Wilson K. and Walker J. (Ed.) Cambridge University Press.
10. Biochemical calculations, Segel I.R., 2nd ed., 2004, John Wiley and Sons
11. An introduction to practical biochemistry 3rd ed., 1998, David T Plummer, Tata McGraw Hill



St. Xavier's College – Autonomous Mumbai

M.Sc. Syllabus For 3rd Semester Courses in **Microbiology** (June 2019 onwards)

Contents:

Theory Syllabus for Courses:

SMIC0901 - MEDICAL AND PHARMACEUTICAL MICROBIOLOGY

SMIC0902 - TOOLS AND TECHNIQUES: BIOMOLECULAR ANALYSIS

SMIC0903 - BIOPROCESS TECHNOLOGY

Practical Syllabus for Courses:

SMIC9PR EXTERNAL PROJECT

M.Sc II

Course: SMIC0901

Title: MEDICAL AND PHARMACEUTICAL MICROBIOLOGY

LEARNING OBJECTIVES:

1. Study significant emerging/reemerging infections and the microbial pathogens involved
2. Learn basic principles of Epidemiology
3. Gain an understanding of clinical research and modern diagnostics

Number of lectures: 60

UNIT 1: EMERGING/RE-EMERGING INFECTIONS

15 LECTURES

LEARNING OBJECTIVES:

Study some significant bacterial pathogens and their associated emerging/ re-emerging infections with special emphasis on advances in diagnostics, prophylactic measures, therapeutics and epidemiology

-
- 1. Study of significant emerging/re-emerging infections-** with emphasis on advances in diagnostics, therapeutics and epidemiology **15L**
- MDR and XDR Tuberculosis
 - MRSA
 - VRE (Vancomycin Resistant Enterococci)
 - Leptospirosis
 - Hepatitis infections
 - Swine flu
 - Dengue
 - Chikungunya
 - Amoebiasis
 - *Candida auris*
 - Japanese encephalitis

UNIT 2: EPIDEMIOLOGY OF INFECTIOUS DISEASES

15 LECTURES

LEARNING OBJECTIVES

1. Learn the history of epidemiology of infectious diseases
2. Get an overview of the principles of epidemiology
3. Know the measurements of risk
4. Understand the significance of public health surveillance and the methods used

1. Historical aspects-definition

1L

2. Descriptive Epidemiology-aims and uses **2L**

3. Epidemiological principles **4L**

- Herd immunity
- Carrier status
- Co-evolution of host-parasite
- Control of epidemics
 - i. Methods directed against reservoir
 - ii. Methods directed against transmission
 - iii. Pathogen eradication

4. Measures of risks: **4L**

- Frequency measures
- Morbidity frequency measures
- Mortality frequency measures
- Natality(birth) measures
- Measures of association
- Measures of public health impact

6. Public health surveillance: **4L**

- Purpose and characteristics
- Identifying health problems for surveillance
- Collecting data for surveillance
- Analyzing and interpreting data
- Disseminating data and interpretation
- Evaluating and improving surveillance

UNIT 3: DRUG DISCOVERY

15 LECTURES

LEARNING OBJECTIVES

1. Understand modern methods of drug discovery.
2. Understand concepts of Pharmacokinetics and Pharmacodynamics.

1. Drug Discovery Tools **7L**

- Pharmacokinetics and Pharmacodynamics, Natural products for lead identification, High Throughput Screening, Combinatorial Chemistry
- Concept of Pharmacognosy

2. Modern Methods of Drug Discovery **6L**

- Cheminformatics, in silico-modelling, Molecular Modeling, Structure Prediction, Rational Drug Designing, Drug Development, Proteomics, protein 3D structures in the drug discovery process, microbial genome mining

3. Clinical trial **2L**
● History, phases and need

UNIT 4: PRINCIPLES OF GMP AND QUALITY PRACTICES IN PHARMACEUTICAL AND COSMETIC INDUSTRY **15 LECTURES**

LEARNING OBJECTIVES

1. Understand GMP and its significance
2. Understand concepts of QA and validation in pharmaceutical and cosmetic products.

1. Principles of GMP, QC, QA, ISO **3L**
● Importance of data integrity in pharmaceutical industry

2. QC and GCLP for Pharmaceuticals **7L**
● Assurance of quality and sanitary practices in the manufacture of sterile products and non-sterile products
● Pharmacopeia test methods and Rapid test methods
● Validation: concepts, principles, analytical methods and applications.

3. Cosmetic microbiology- testing methods and reservation **5L**
● Antimicrobial preservation efficacy and microbial content testing
● Validation method for cosmetics
● Preservation strategy - Global regulatory and toxicological aspects
● Evaluation of antimicrobial mechanism

CIA: Assignment, Test

References:-

Unit 1

1. Clinics in laboratory medicine, Emerging Infections and their causative agents. September 2004 vol. 24 no. 3.
2. Koneman's color Atlas & Textbook of Diagnostic Microbiology, Winn, C. W., Allen, D. S., Janda, M. W., Koneman, W. E., Schreckenberger, C. P., Procop, W. G. and Woods, L. G., 6th edition, 2005, Lippincott Williams & Wilkins.
3. Textbook of Microbiology, Ananthanarayan & Paniker, 9th edition, 2013, University press

Unit 2

1. Basic lab methods in medical bacteriology, WHO Geneva.

2. Epidemiology for Public Health Practice- Friis, H. R., & Sellers, A. T., 4th edition, 2009, Jones & Bartlett publishers.
3. Handbook of Epidemiology- Ahrens, W., Pigeot, I., 2005 Springer- Verlag Berlin Herdelberg.
4. Infectious disease surveillance, Nikuchia, N., 2005, Blackwell Publishing.
5. Medical Laboratory Technology, Godkar, P. & Godkar, D., 2nd edition, 2006, Bhalani Publishing House.
6. Park's Textbook of Preventive and Social Medicine, Park, K., 16th edition, 2000, M/S Banarsidas Bhanot
7. Principles of epidemiology in public health practices 3rd edition
www.cdc.gov/training/products/ss1000

Unit 3:

1. Foye's Principles of Medicinal Chemistry, Lemke T. L. and Williams D. A., 6th Ed, 2008, Wolter Luwer, Lippincott Williams and Wilkins. N Delhi.
2. Modern Methods of drug discovery, Hillisch A. and Hilgenfeld R., 2009, Springer International Edition
3. Principles of Medicinal Chemistry, Kadam S. S., Mahadik K. R. and Bothara K. G., 2009, Vol II, Nirali Prakashan Pune
4. Principles of pharmacology: the pathophysiologic basis of drug therapy by Golan D. E., 2nd Edition, 2007, Lippincott Williams and Wilkins

Unit 4:

1. Cosmetic Microbiology a practical approach, Geis P. A., Taylor and Francis, 2nd Ed, 2006, CRC Press
2. Guidelines on cGMP and quality of Pharmaceutical products, Iyer S., 2003, D K Publishers Mumbai.
3. Hugo and Russell's Pharmaceutical Microbiology, Denyer S. P., Hodges N. A., Gorman S. P. And Gilmore B., 8th Edition, 2011, Blackwell Publishing.
4. Quality Assurance in Microbiology, Bhatia R. and Ichhapujani R. L. 1995, CBS publishers and distributors
5. Quality in the manufacture of medicines and other healthcare products, Sharp John, 2000, Pharmaceutical Press.
6. USPs

M. Sc. II

Course: SMIC0902

Title: TOOLS AND TECHNIQUES: BIOMOLECULAR ANALYSIS

LEARNING OBJECTIVES

Understand principles and applications of bioanalytical techniques

Number of lectures: 60

UNIT 1: TOOLS AND TECHNIQUES: MICROSCOPY, X-RAY DIFFRACTION AND CD/ORD **15 LECTURES**

LEARNING OBJECTIVES

Understand the principles, methods and applications of Microscopic techniques and X-ray diffraction

1. Advanced microscopic techniques: principles and applications **7L**

Scanning Probe Microscopes - scanning tunneling microscope (STM), magnetic force microscope (MFM), scanning near field microscope (SNOM)
Electron Microscopy

2. Diffraction techniques **4L**

X-ray diffraction (XRD)

3. Circular Dichroism (CD) and Optical rotator Dispersion (ORD) **4L**

UNIT 2: TOOLS AND TECHNIQUES: SPECTROSCOPY **15 LECTURES**

LEARNING OBJECTIVES

Understand principles, working and applications of different spectroscopic and electrophoretic techniques

1. Infrared spectroscopy **2L**

- Principles, Instrumentation, operation, calibration, accuracy and applications

2. Electron Spin Resonance (ESR) Spectrometer: principle and application **2L**

- 3. Atomic Absorption Spectroscopy** **2L**
- Principles, Instrumentation, operation, calibration, accuracy and applications
- 4. NMR spectroscopy** **5L**
- Basic Principles of NMR, Chemical shift, Intensity, Line width
 - Theory and application
- 5. Mass spectroscopy** **4L**
- Instrumentation
 - Various detection systems including MALDI-TOF

UNIT 3: TOOLS AND TECHNIQUES: CHROMATOGRAPHY **15 LECTURES**

LEARNING OBJECTIVES

Understand principles, working and applications of different chromatographic techniques

-
- 1. Gas Chromatography** **5L**
- Principles, Instrumentation, operation, calibration, accuracy and applications
- 2. High Performance Liquid Chromatography** **7L**
- Principles, Instrumentation, operation, calibration, accuracy and applications
- 3. Supercritical Liquid Chromatography** **3L**
- Properties of SFE/SFC, Instrumentation, operation, advantages and applications

UNIT 4: OTHER ANALYTICAL TECHNIQUES **15 LECTURES**

LEARNING OBJECTIVES

Understand different methods and principles used in analytical techniques.

-
- 1. Centrifugation** **4L**
- Overview of preparative and analytical centrifuges, differential centrifugation, sedimentation velocity, sedimentation equilibrium, density gradient methods and their applications
- 2. Radioisotopic techniques** **6L**
- Use of radioisotopes in life sciences, radioactive labeling, principle and application of tracer techniques, detection and measurement of radioactivity using ionization chamber, proportional chamber, Geiger- Muller and Scintillation counters, autoradiography and its applications.
 - Dosimetry.

3. Electrophoretic techniques and application **3L**

4. Hybridization techniques/Microarray **2L**

CIA: Assignment, Test

References: -

Unit 1:

1. Bioimaging: current concepts in light and electron microscopy, Chandler D.E. and Roberson R.W. 2009, Singapore, Jones and Bartlett Publishers
2. Biophysical Chemistry: Principles and Techniques, Upadhyay, Upadhyay and Nath, 2014, Mumbai, Himalaya Publishing House
3. Handbook of Physics in Medicine and Biology, edited by Robert Splinter, 2010, CRC Press
4. Principles of Physical Biochemistry 2nd Edition, van Holde, E. Kersal, W.C. Johnson, H. P. Shing, 2006, New Jersey, Pearson Prentice Hall

Unit 2:

1. Atomic absorption and plasma spectroscopy, Dean J.R., 1997 (2008), Wiley India Pvt. Ltd. (Analytical Chemistry by Open Learning series)
2. Biophysical Chemistry: Principles and Techniques, Upadhyay, Upadhyay and Nath, 2014, Mumbai, Himalaya Publishing House
3. http://faculty.sdmiramar.edu/fgarces/labmatters/instruments/aa/AAS_Theory/AASTheory.htm
4. http://www.brynmawr.edu/chemistry/Chem/mnerzsto/The_Basics_Nuclear_Magnetic_Resonance%20_Spectroscopy_2.htm
5. Mass spectroscopy, Barker J., 2008, Wiley India Pvt. Ltd. (Analytical Chemistry by Open Learning series)
6. NMR spectroscopy, Williams D.A.R., 2008, Wiley India Pvt. Ltd. (Analytical Chemistry by Open Learning series)
7. Principles of Instrumental Analysis, 5th Ed. Skoog D. A., Holler F.A., Crouch S.R., Holler and Nieman, Australia

Unit 3:

1. Basic Gas Chromatography, McNair H. M. and Miller J. M., 2009, Wiley International
2. Biophysical Chemistry: Principles and Techniques, Upadhyay, Upadhyay and Nath, 2014, Mumbai, Himalaya Publishing House

3. Gas Chromatography, Fowles I. A., 2008, Wiley India Pvt. Ltd. (Analytical Chemistry by Open Learning series)
4. HPLC, Lindsay S., 2008, Wiley India Pvt. Ltd. (Analytical Chemistry by Open Learning series)

Unit 4:

1. Biophysical Chemistry: Principles and Techniques, Upadhyay, Upadhyay and Nath, 2014, Mumbai, Himalaya Publishing House
2. Centrifugation: a practical approach, edited by D. Rickwood, 1984, Oxford
3. Molecular cloning: A laboratory Manual, Sambrook J., Fritsch, Maniatis T, 2nd edition, 1989, Cold Spring Harbor Laboratory Press
4. Wilson and Walker's Principles and techniques of biochemistry and molecular biology, Hofmann A., Clokie S., 2018, 8th Ed., Cambridge University Press, UK

M.Sc II

Course: SMIC0903

Title: BIOPROCESS TECHNOLOGY

LEARNING OBJECTIVES

1. Understand the basic principles and applications of bioprocess technology
2. Understand the concepts of bioprocess technology including fermentation kinetics and process design and apply them to microbial bioprocesses
3. Understand the concept of IPR, bioethics and entrepreneurship

Number of lectures: 60

**UNIT 1: BIOPROCESS TECHNOLOGY
LECTURES**

15

LEARNING OBJECTIVES

Understand the general principles of bioprocess technology and upstream process

1. General principles of fermentation

7L

- Aeration - Theory of oxygen transfer in bubble aeration, Oxygen transfer kinetics (Oxygen Uptake Rate –OUR; Oxygen Transfer Rate OTR; Ccrit), determination of KLa.
- Agitation
- Kinetics of growth in batch culture, continuous culture with respect to substrate utilization, specific growth rate, steady state in a chemostat, fed-batch fermentation, yield of biomass and product, calculation for productivity, substrate utilization kinetics, growth limiting substrate, maintenance energy

2. Upstream processing

3L

- Media formulation, modification and optimization
- Inoculum development and storage of cultures

3. Microbial strain improvement

3L

- Screening and isolation of microorganisms
- Use of genetic manipulation for strain improvement
- Problems associated with strain improvement; improvement of characters other than products

4. Sterilization

2L

- Sterilization of bioreactors, nutrients, air supply, product and effluents

UNIT 2: FERMENTATION PROCESSES IN BIOTECHNOLOGY **15**
LECTURES

LEARNING OBJECTIVES

Understand concepts of microbial fermentation and downstream processing

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- | | |
|---|-----------|
| 1. Measurement and control of bioprocess parameters | 3L |
| <ul style="list-style-type: none">● Automation for monitoring and Control (online and offline sensors, Biosensors)● Use of Computers: Data logging, data analysis, and process control | |
| 2. Bioreactor | 3L |
| <ul style="list-style-type: none">● Basic configuration and features. Reactors for specialized applications: Tube reactors, packed bed reactors, fluidized bed reactors, cyclone reactors, trickle flow reactors, photobioreactors- their basic construction and types for distribution of gases. | |
| 3. Downstream processing | 3L |
| <ul style="list-style-type: none">● Biomass separation by centrifugation, filtration, flocculation and other methods.● Cell disintegration: Physical, chemical and enzymatic methods.● Extraction: Solvent, two phase, liquid extraction, whole broth, aqueous multiphase extraction. Purification by different methods.● Concentration by precipitation, ultrafiltration, reverse osmosis, drying and crystallization | |
| 4. Scale-up of Bioprocess | 2L |
| 5. Microbial Fermentations | 3L |
| <ul style="list-style-type: none">● Industrial production of citric acid, enzymes (e.g. proteases), acetone- butanol, amino acids (e.g. lysine) by submerged and/or solid state fermentation. | |
| 6. Effluent treatment | 1L |

UNIT 3: ADVANCES IN BIOPROCESSES **15 LECTURES**

LEARNING OBJECTIVES

Understand the advanced methods of microbial bioprocesses.

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- | | |
|---|-----------|
| 1. Recent approaches in microbial production | 5L |
| <ul style="list-style-type: none">● Bioplastics, Biopesticides, Biopolymer, Biofertilizers, Single Cell Protein | |
| 2. Biofuels | 3L |

3. Microbial fuel cell **2L**

4. Immobilization techniques **5L**

- Whole cell and enzyme immobilization, Application and advantages of cell and enzyme immobilization in pharmaceutical, food and fine chemical industries.
- Kinetics of immobilized enzymes.

UNIT 4: IPR, ETHICS AND ENTERPRENEURSHIP

15 LECTURES

LEARNING OBJECTIVES:

1. Understand IPR and its role
2. Understand the concept of bioethics and its relevance
3. Understand the concept of entrepreneurship in biotechnology and obtain a preliminary knowledge of its components

1. Biotechnology and Intellectual Property Rights **7L**

- Intellectual Property Rights (IPR) and Protection (IPP)
- Biotechnology and IPR-Rationale of Patent in Research and Scientific Innovations
- Biotechnological Patents
- Requirements for Patentability- Patentable subject matter, Novelty, Invention in Biotechnological Research, Industrial Applicability, Enablement Requirement.
- Patent Specifications and Basic Component of License Agreement, In IP System
- Categories of Biotechnological Patents-Patenting in New Era of Genomics, Proteomics and Microbiology, Examples of Patents granted by USPTO, Concerns over Biotechnology Patents.
- Patenting in Biotechnology-European Scenario, US Scenario, Australia Scenario, Indian Scenario, Non-Patentable IP and Patentable IP in Indian Patent Act

2. Biotechnology and Bioethics **3L**

- Bioethics and cross-cultural bioethics. - Autonomy, Rights, Beneficence, Do No Harm, Justice, Confidentiality, Animal Rights, Environmental ethics, Decision-Making
- Perceptions of Ethical Biotechnology, Reasoning behind Acceptance or Rejection of Genetic Manipulation, Concerns about consuming products of GMOs.
- Future 'Bioethical Conflicts' in Biotechnology. - Changing perception of Nature, Human Genetic Engineering

3. Biosafety **2L**

- Historical background and introduction
- Need of biosafety levels, biosafety guidelines for GMOs and LMOs. Role of Institutional biosafety committee
- RCGM, GEAC, etc. for GMO applications in food and agriculture. Environmental release of GMOs

- Overview of national regulations and relevant international agreements. Ecolabelling, IS 22000, Generally Recognized as Safe (GRAS)

4. Entrepreneurship in biology

3L

- Introduction
- Case Studies in Entrepreneurship
- Entrepreneurial Skills
- Initiating a Venture
- Planning a Venture
- Financing a Venture

CIA: Test, Creation of study material or teaching aids (eg PPT, working model, chart, game etc)

References: -

Unit 1, 2 and 3:

1. Biochemical Engineering: A Textbook for Engineers, Chemists and Biologists. Katoh, S., Horiuchi, J. and Fumitake Y. 2nd edition, Wiley-VCH Verlag GmbH & Co. KGaA (2015)
2. Bioprocess engineering principles. Doran, P. M., 2nd edition, Amsterdam; Boston: Elsevier/Academic Press (2013)
3. Bioprocess Engineering: basic concepts. Shuler, M. L. & Kargi, F. Prentice Hall Publishers, New York (1992)
4. Bioreaction engineering principles. Villadsen, J., Nielsen, J. H., Lidén, G., & Nielsen, J. H., 3rd ed. New York: Springer. (2011)
5. Crueger's Biotechnology: A textbook of industrial microbiology. Crueger, W. & Crueger, A., 3rd ed., Medtech Scientific International Pvt. Ltd. (2017)
6. Fermentation and biochemical engineering handbook: Principles, process design, and equipment. Vogel, H. C., & Todaro, C. L. (Eds.), 2nd ed., Westwood, N.J., U.S.A: Noyes Publications. (1997)
7. Microbial Biotechnology: Fundamentals of Applied Microbiology. Glazer A. N. & Nikaido H. W.H. Freeman & Company, New York (1995)
8. Microbial Technology Volume 1 and 2. Pepler H. J. and Perlman D., Academic Press New York (1970)
9. Modern industrial microbiology and biotechnology. Okafor, N., Enfield, (NH): Science Publishers. (2007)
10. Practical fermentation technology. McNeil, B., & Harvey, L. M. Chichester, England; Hoboken, NJ: Wiley (2008)
11. Principles and applications of fermentation technology. Kuila, A., & Sharma, V. (Eds.), Hoboken, New Jersey: Wiley. (2018)
12. Principles of Fermentation Technology. Stanbury P.F., Whitaker W. & Hall S. J., Aditya Books (P) Ltd., New Delhi (1997)

13. Principles of fermentation technology. Stanbury, P. F., Whitaker, A., & Hall, S. J., 3rd ed. Amsterdam: Butterworth-Heinemann, an imprint of Elsevier. (2017)
14. Upstream industrial biotechnology. Flickinger, M. C. (Ed.), Hoboken, New Jersey: John Wiley & Sons Inc. (2013)

Unit 4:

1. Bioethics and Biosafety in Biotechnology, Sree Krishna V., New Age International (P) Limited. (2017)
2. Bioethics and Biosafety, Sateesh, M. K., I. K. International Publishing House Pvt. Ltd. (2008)
3. IPR, biosafety, and bioethics. Goel, D., & Parashar, S., Dorling Kindersley (India). (2013)
4. Molecular Biotechnology: Principles and Applications of Recombinant DNA, Bernard R. Glick, Jack J. Pasternak, 4th ed., ASM Press (2010)

M.Sc II

Course: SMIC09PR

Practicals

EXTERNAL PROJECT (THREE TO FOUR MONTHS)

Evaluation

CIA		End semester	
Detail	Marks	Detail	Marks
Evaluation of the student by the supervisor of the external project	100	Evaluation of project presentation by internal and external examiner	30
Oral presentation of the external project	20	Evaluation of project thesis by internal and external examiner	120
-	-	Evaluation of project viva by internal and external examiner	30
	120 (total)		180 (Total)



St. Xavier's College (Autonomous)
Mumbai

M.Sc. Syllabus
For 4th Semester Courses in **Microbiology**
(June 2019 onwards)

Contents:

Theory Syllabus for Courses:

SMIC1001 - **MICROBIAL ECOLOGY AND ENVIRONMENTAL
MICROBIOLOGY**

SMIC1002 - **FOOD MICROBIOLOGY**

SMIC1003 - **CELLS IN THEIR SOCIAL CONTEXT**

SMIC1004 - **ADVANCES IN BIOTECHNOLOGY**

Practical Syllabus:

SMIC1001PR: **INTERNAL PROJECT**

SMIC1002PR: **INTERNAL PROJECT**

SMIC1003PR: **FOOD, PHARMACEUTICAL AND COSMETIC MICROBIOLOGY**

SMIC1004PR: **ENVIRONMENTAL MICROBIOLOGY, ANIMAL TISSUE
CULTURE AND NANOTECHNOLOGY**

Title: MICROBIAL ECOLOGY AND ENVIRONMENTAL MICROBIOLOGY
Course SMIC1001

LEARNING OBJECTIVES

1. Understand the role of microorganisms in different ecosystems
2. Understand the interactions of microbes with each other and higher organisms
3. Understand the principles of techniques used in microbial ecology
4. Learn the application of microorganisms in bioremediation and waste disposal

Number of lectures: 60

UNIT 1 MICROBIAL ECOLOGY: MICROBIAL ENVIRONMENTS AND BASIC CONCEPTS IN MICROBIAL ECOLOGY **15 LECTURES**

LEARNING OBJECTIVES

1. Understand the role of microorganisms in biogeochemical cycling
2. Understand microbial biodiversity in different habitats
3. Know the adaptations of microorganisms to extreme environmental conditions
4. Understand the role of microbiomes

1. Introduction to ecological concepts	1L
2. Biogeochemical cycles/nutrient cycling in environments	2L
3. Microorganisms in Aquatic environments	3L
4. Microorganisms in Terrestrial environments	3L
5. Microorganisms in Extreme environments	3L
6. Microbiomes	3L

UNIT 2 MICROBIAL ECOLOGY: INTERACTIONS AND BIOFILMS **15 LECTURES**

LEARNING OBJECTIVES

1. Understand the concepts in interaction of microbes with each other and also with higher organisms
2. Know biofilm formation in various environments

1. Microbial interactions	10L
<ul style="list-style-type: none">• Symbiosis between microorganisms• Plant microbial interactions• Insects as microbial habitats• Mammals as microbial habitats• Aquatic invertebrates as microbial habitats	
2. Microbial biofilms	5L

UNIT 3 TECHNIQUES IN MICROBIAL ECOLOGY **15 LECTURES**

LEARNING OBJECTIVES

Understand the use of various techniques involved in microbial ecology

- 1. Environmental sample collection and processing** **2L**
- 2. Culture based methods** **1L**
- 3. Physiological methods** **3L**
 - Measuring microbial activity in pure culture
 - Carbon respiration
 - Stable isotope probing
 - Use of radioisotopes as tracers
 - Adenylate energy charge
 - Enzyme assays
- 4. Nucleic acid-based methods of analysis** **6L**
 - Obtaining nucleic acids from environment
 - Use of gene probes
 - FISH, ISRT FISH, CARD FISH
 - Microarrays
 - PCR – RTPCR, qPCR, ICC PCR, PCR-fingerprinting
 - RFLP
 - ARISA, ARDRA
 - Denaturing /Temperature gradient gel electrophoresis
- 5. Microbial community analysis of environmental samples with next-generation sequencing** **3L**
 - Introduction to microbial community analysis of environmental samples with NGS/TGS
 - Microbial community analysis using High-Throughput Amplicon Sequencing
 - Functional Metagenomics: Procedures and Progress
 - Metagenomics: Assigning functional status to community gene content
 - Generation and analysis of microbial metatranscriptomes

UNIT 4 BIOREMEDIATION AND WASTE DISPOSAL

15 LECTURES

LEARNING OBJECTIVES

1. Understand the bioremediation process and its feasibility.
2. Learn the various methods of bioremediation.
3. Learn the various methods of sewage treatment
4. Understand solid and hazardous waste management

-
- 1. Introduction to bioremediation** **2L**
 - Factors affecting bioremediation – nutrient sources, environmental conditions, bioavailability, adsorption/desorption kinetics
 - Needs and limitations
 - Strategies for bioremediation
 - 2. Types of bioremediation with examples** **4L**

- Intrinsic and enhanced: Indigenous and bioaugmentation,
- In-situ bioremediation: Bioventing, Biosparging, Bioslurping
- Ex-situ bioremediation: Land farming, Composting, Biopile process, Bioreactors
- Novel technologies
- Molecular methods for bioremediation

3. Sewage and sludge treatment and disposal **4L**

- Aerobic processes
- Anaerobic processes
- Plant loading criteria – MLSS, TSS, HRT, MCRT, F:M
- Disposal methods

4. Solid waste management **3L**

5. Hazardous waste management **2L**

CIA: Visit/project on waste management, Test

References:-

Unit 1:

1. A review of 10 years of human microbiome research activities at the US National Institutes of Health, Fiscal Years 2007-2016, Microbiome 2019.
2. Advances in Environmental Microbiology Volume 1 Editor Christon J. Hurst, Cincinnati, OH, USA Universidad del Valle, Cali, Colombia, Springer 2016
3. Brock Biology of microorganisms, Madigan, Martinko, Dunlap, Clara, 14th and 15th Ed., 2015, 2017, Pearson Intl Ed., USA.
4. Environmental Microbiology: Fundamentals and Applications: Microbial Ecology, Ed. by Jean-Claude Bertrand (Editor), Pierre Caumette (Editor), Philippe Lebaron (Editor), Robert Matheron (Editor), Philippe Normand (Editor), Télesphore Sime-Ngando (Editor), 2015, Springer USA
5. Manual of Environmental Microbiology, Marylynn Yates, 2016, ASM press, USA
6. Microbial Ecology - Fundamentals and Applications, Atlas R. M. and Bartha R., 1998, Addison Wesley Longman, Inc., USA
7. Prescott's Microbiology, Willey J. M., Sherwood, L. M., Woolverton, C. J., 2014, 10th Ed., McGraw Hill Education, USA.

Unit 2:

1. Environmental Microbiology: Fundamentals and Applications: Microbial Ecology, Ed. by Jean-Claude Bertrand (Editor), Pierre Caumette (Editor), Philippe Lebaron (Editor), Robert Matheron (Editor), Philippe Normand (Editor), Télesphore Sime-Ngando (Editor), 2015, Springer USA.
2. Bacterial biofilms: from the Natural environment to infectious diseases, Hall-Stoodley, L., Costerton, J. & Stoodley, P. Nat Rev Microbiol 2, 95–108 (2004). <https://doi.org/10.1038/nrmicro821>.
3. Biofilm formation as microbial development, O'Toole, G., Kaplan, H. B. and Kolter, R., 2000, Annu. Rev. Microbiol. 2000. 54:49–79.
4. Biofilms: An emergent form of bacterial life, Flemming, H.C.; Wingender, J.; Szewzyk, U.; Steinberg, P.; Rice, S.A.; Kjelleberg, S., Nat. Rev. Microbiol. 2016, 14, 563–575.
5. Brock Biology of microorganisms, Madigan, Martinko, Dunlap, Clara, 14th and 15th ed, 2015, 2017, Pearson Intl Ed, USA.

6. Prescott's Microbiology, Willey J. M., Sherwood, L. M., Woolverton, C. J., 2014, 10th Ed., McGraw Hill Education, USA.

Unit 3:

1. A review of methods and databases for metagenomic classification and assembly Florian P. B., Jennifer L., Salzberg S. L., Briefings in Bioinformatics, Volume 20, Issue 4, July 2019, Pages 1125–1136, <https://doi.org/10.1093/bib/bbx120>
Published: 23 September 2017.
2. Brock Biology of microorganisms, Madigan, Martinko, Dunlap, Clara, 14th and 15th ed, 2015, 2017, Pearson Intl Ed, USA.
3. Environmental Microbiology, Maier R. M., Pepper. L. and Gerba C. P., 2010, Academic Press, USA.
4. Manual of Environmental Microbiology, 2016, Marylynn Yates, ASM press.
5. Microbes and Microbial Technology, Rastogi & Sani, 2011, pp 29-57, Molecular Techniques to Assess Microbial Community Structure, Function, and Dynamics in the Environment in Microbes and Microbial Technology: Agricultural and Environmental Applications, Edited by Ahmad I., Ahmad F., Pichtel J., 2011, Springer Verlag New York, USA.
6. The Metagenomics of soil, Rolf Daniel, 470/June2005/vol3, www.nature.com/reviews

Unit 4:

1. A Textbook of Biotechnology, Dubey R. C., Illustrated Revised Ed., 2010, S and Singleton I.; J Chemical Technology and Biotechnology, 80: 723-736, 2005.
2. Approaches in Bioremediation: The New Era of Environmental Microbiology and Nanobiotechnology, Edited by Ram Prasad, Aranda E., 2018, Springer, USA
3. Bioremediation of BTEX hydrocarbons, Prenafeta-Boldu, F.X. et. al Biodegradation, 15:59-65. 2004.
4. Bioremediation of PAH: Current knowledge and future directions, Bamforth S.M.
5. Bioremediation: Principles and Applications, Crawford R. L. and Crawford D. L., 1st Ed. (September 8, 2005), Cambridge University Press Chand and company, India.
6. Environmental Biotechnology, Allan Scragg, 2nd Ed., 2005, Springer, USA
7. Environmental Biotechnology. Fulekar, M. H., 2010, CRC Press and Science.
8. Environmental Microbiology, Maier R. M., Pepper I. L. and Gerba C. P., 2nd Ed., 2009, Academic Press, USA.
9. <http://www.indiaenvironmentportal.org.in/content/249593/guidelines-for-environmentally-sound-management-of-e-waste/>
10. <http://www.mpcb.gov.in/waste-management/common-effluent-treatment-plant>
11. In situ and ex situ biodegradation technologies for remediation of contaminated sites, Rawe, J., V. Hodge, C. M. Acheson, C. Lutes, and D. Liles. (Engineering issue). EPA/625/r-06/015, 2006.
12. Wastewater engineering: Treatment and reuse, Metcalf and Eddy, 4th Ed. 2004
Tata McGraw Hill Publishing Co. Ltd, India

Title: FOOD MICROBIOLOGY

Course: SMIC1002

LEARNING OBJECTIVES

1. Understand significance of microbes in food and their control
2. Understand concepts of food Safety, quality management and regulation in the food industry

Number of lectures: 60

UNIT 1. MICROBES, THEIR GROWTH RESPONSE IN FOOD AND FOOD SPOILAGE **15LECTURES**

LEARNING OBJECTIVES

1. Understand the incidence of microbes in food and their role in food spoilage.
2. Understand biofilm formation and microbial stress in foods.
3. Predicting the growth of micro-organisms in foods

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- | | |
|---|-----------|
| 1. Microbes in foods | 2L |
| <ul style="list-style-type: none">• Important microorganism groups in food and their sources• Normal microbiological quality of food and its significance | |
| 2. Factors influencing microbial growth in food | 5L |
| <ul style="list-style-type: none">• Intrinsic and extrinsic factors• Biofilm formation in foods and assessment• Microbial stress responses in the food environment• Importance of spores in foods | |
| 3. Microbial food spoilage | 5L |
| <ul style="list-style-type: none">• Important factors in microbial food spoilage• Spoilage of specific foods• New spoilage bacteria in refrigerated food• Food spoilage by enzymes• Indicators of microbial food spoilage | |
| 4. Predictive modeling of microbial growth in food | 3L |
| <ul style="list-style-type: none">• Traditional methods and shelf life studies• Mathematical models: developing a model, types of models• Softwares: ComBase Browser and Predictor | |

UNIT 2: CONTROL OF MICROBES IN FOOD

15 LECTURES

LEARNING OBJECTIVES

1. Know the principles of traditional and novel techniques used in food preservation to control the access and growth of microorganisms in food
2. Learn principles of food packaging

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- | | |
|--|-----------|
| 1. Control of access of microbes in foods | 1L |
| <ul style="list-style-type: none">• Cleaning, sanitation and disinfection in food handling operations• Removal of biofilm | |

- 2. Control by physical agents** **5L**
- Physical removal
 - Thermal Processing: mathematical expressions, low heat and high heat processing
 - Irradiation
 - Reducing water activity and drying
 - Low temperature
- 3. Control by chemical agents** **1L**
- Low pH and organic acids
 - Antimicrobial preservatives and bacteriophages
 - Modified atmosphere
- 4. Control by a combination of methods (Hurdle Concept)** **1L**
- 5. Control by novel processing technology** **3L**
- Microwave and infrared heating
 - Ohmic and inductive heating
 - Pulsed electric fields processing
 - High pressure processing
 - Pulsed light technology
 - Pulsed X-rays
 - Plasma technology
- 6. Food packaging** **4L**
- Functions of packaging
 - Packaging materials and uses
 - Aseptic packaging
 - Innovations in packaging and future trends

UNIT 3: BENEFICIAL USES OF MICROBES AND OTHER FORMULATIONS IN FOOD **15 LECTURES**

LEARNING OBJECTIVES:

1. Understand general production methods of ethnic Indian fermented foods from milk, meat, vegetables and cereals.
2. Know the other applications of microbes and microbial products in the food industry
3. Understand functional foods especially nutraceuticals.
4. Understand the production of packaged drinking water and its final quality

1. Microbiology of ethnic fermented foods of India **4L**

- Fermented cereal and cereal-legume mixture foods: e.g. Ambali, Bhatooru, Jalebi, Nan, Selroti, Seera, Adai Dosa.
- Fermented soyabean foods, non-soybean legume foods: e. g. Bekang, Kinema, Dhokla and Khaman, Masyaura and Wari
- Indian fermented dairy products: e.g. Dahi and Lassi, Chhurpi and Chhu, Shrikhand, and Misti dahi,

- Indian fermented fish and meat products: **e.g.** Fish - Gnuchi, Hentak, Karati, Bordia and Lashim, Sidra; Meat - Suka ko Masu, Chartayshya, Jamma or Geema/Juma, Kargyong

2. Food additives of microbial origin **5L**

- Enzymes
- Biopreservatives
- Sweetners, flavours and colors
- Probiotics and prebiotics

3. Nutraceuticals **4L**

- Introduction to nutraceuticals - definitions, basis of claims for a compound as a nutraceutical, regulatory issues for nutraceuticals.
- Production of nutraceuticals like lycopene, isoflavonoids, prebiotics and probiotics, glucosamine, phytosterols
- Applications of fibers from food sources
- Microbial fructooligosaccharides

4. Packaged water **2L**

- Types of bottled water
- BIS /regulations regarding the production of packaged waters with respect to final quality of product
- Potential chemical and microbiological hazards in the bottles depending on the type of water, the type of bottle and the bottling procedure
- Chemical and microbial indicators and limits in potable water
- The application of HACCP in the bottling plan

UNIT 4: METHODS FOR FOOD SAFETY **15 LECTURES**

LEARNING OBJECTIVES

1. Understand important facts of microbial food borne diseases.
2. Understand conventional, modern and rapid methods of detection of microbes and their products in food.
3. Be able to apply concepts of QA, QC, GMP, ISO 22000 and HACCP in food industry
4. Understand laboratory accreditation criteria.

1. Microbial foodborne diseases **2L**

- Important facts in food borne diseases
- Food Borne infections
- Food Borne intoxicants
- Foodborne toxico-Infections
- Opportunistic pathogens
- New and emerging food pathogens
- Indicators of bacterial pathogens

2. Methods for detection of microbes and their products **5L**

- Conventional microbiological methods
 - i. Sampling schemes for microbial analysis

- ii. Microbial enumeration in food
- iii. Qualitative methods for detection of microbes and their toxins in food
- Chemical methods
 - i. DNase test
 - ii. LAL test
 - iii. Tests with fluorogenic and chromogenic substrates
- Immunological methods
 - i. FAT
 - ii. ELISA
 - iii. RIA
 - iv. Hemagglutination
- Molecular Methods
 - i. PCR
 - ii. Lux gene luminescence
 - iii. Fingerprinting methods
- Physical Methods
- Biosensors in food analysis
- Laboratory accreditation

3. Controlling the microbiological quality of food and food safety

8L

- Quality Control using microbiological criteria
- Food laws and regulation, FSSAI, Codex Alimentarius and other quality standards
- Quality Management, HACCP, FSMS /ISO 22000
- Risk Analysis for safe food supply
- Food safety in food service establishments and on the street

CIA: Presentation, Test

References:

Unit 1:

1. Food Microbiology, Adams M. R. and Moss M. O., 3rd Ed., 2008, RSC Publishing, Cambridge, UK.
2. Fundamental Food Microbiology, Bibek R. and Bhunia A., 5th Ed., 2014, CRC Press, USA.
3. Modeling in food Microbiology: From predictive microbiology to exposure assessment, Edited by Membre J. M., Valdramidis V., 2016, Elsevier Ltd and ISTE press, UK.
4. Modern Food Microbiology, Jay J., Loessner M. and Golden D., 7th Ed., 2005, Springer, USA.
5. Predictive Modeling of Microbial Behavior in Food, Stavropoulou & Bezirtzoglou, E. (2019). Foods. 8. 654. 10.3390/foods8120654.

Unit 2:

1. Food Microbiology, Adams M. R. and Moss M. O., 3rd Ed., 2008, RSC Publishing, Cambridge, UK.
2. Food Packaging: Principles and practice, Robertsn G.L., 2013, CRC Press, USA
3. Food processing and preservation, Subbulakshmi G., Udipi S. A., 2006, New Age International, New Delhi.
4. Fundamental Food Microbiology, Bibek R. and Bhunia A., 5th Ed., 2014, CRC

Press, US.

5. Innovations in Food Packaging, in Food Science and Technology International Series, Edited by Han J.H., 2014, Elsevier, Academic press, UK.
6. Modern Food Microbiology, Jay J., Loessner M. and Golden D., 7th Ed., 2005, Springer, USA.

Unit 3:

1. Biotechnology- Food Fermentation: Microbiology, Biochemistry, and Technology, Volume 2, Joshi V. K., Pandey A., 1999, Educational publishers and distributors, India.
2. Ethnic Fermented Foods and Alcoholic Beverages of Asia, Edited by Tamang J.P., 2016, Springer, India.
3. Food Microbiology, Adams M. R. and Moss M. O., 3rd Ed., 2008, RSC Publishing, Cambridge, UK.
4. Functional Foods – Concept to Product, Gibson GR & William CM., 2000, Woodhead Publishing, CRC press, USA.
5. Fundamental Food Microbiology, Bibek R. and Bhunia A., 5th Ed., 2014, CRC Press, US http://www.bis.org.in/qazwsx/cmd/water_manual_final.pdf
6. Manual for packaged drinking water, Bureau of Indian Standards, third issue, Doc No.: SM/IS14543 & IS13428/03 2013.
7. Model code, Bottled water code of practice, 2012, International bottled water association, USA.
8. Modern Food Microbiology, Jay J., Loessner M. and Golden D., 7th Ed., 2005, Springer, USA.
9. Nutraceuticals - Global status and applications: A Review, Sapkale A. P., Thorat M. S., Vir Prasad R. and Singh M. C. International Journal of Pharmaceutical and Chemical Sciences, Vol. 1 (3) Jul-Sep 2012.
10. Nutraceuticals - Global status and applications: A Review, Sapkale A. P., Thorat M. S., Vir Prasad R. and Singh M. C. International Journal of Pharmaceutical And Chemical Sciences, Vol. 1 (3) Jul-Sep 2012.
11. Nutraceuticals and natural product derivative: disease prevention and drug discovery, Edited by Ullah M.F., Ahmad A., 2019, John Wiley sons, USA.
12. Nutraceuticals as therapeutic agents: A Review, Rajasekaran A., Sivagnanam G. and Xavier R., Research J. Pharm. and Tech. 1(4): Oct.-Dec. 2008,328-340.
13. Prescott and Dunn's Industrial Microbiology, Reed G., 4th Ed., 2004, CBS Publishers, India.

Unit 4:

1. Food Microbiology and Food Safety Practical Approaches, Edited by King H., 2013, Springer, NY.
2. Food Microbiology, Adams M. R. and Moss M. O., 3rd Ed., 2008, RSC Publishing, Cambridge, UK.
3. Food safety and quality control, Mathur P., 2018, Orient Blackswan Private Ltd., Hyderabad.
4. Food safety and standards act, 2006 (Act No. 34 of 2006), 2019, Kamal Publishers, New Delhi.
5. Food safety officer examination (A subjective approach, Chandra S., Kumari Durvesh, 6th Ed., 2020, Jain Brothers, New Delhi.
6. Fundamental Food Microbiology, Bibek R. and Bhunia A., 5th Ed., 2014, CRC Press, USA.

7. Lab Manual 14, FSSAI, Manual of methods of analysis of foods Microbiological testing, 2012, Food safety and standards authority of India, Ministry of health and family welfare, Government of India.
8. Laboratory manual of food microbiology, Garg N., Garg K.L., Mukerji K.G., 2010, IK International Publishing House, New Delhi.
9. Modern Food Microbiology, Jay J., Loessner M. and Golden D., 7th Ed., 2005, Springer, USA.
10. www.codexalimentarius.org WHO, FAO
11. www.codexindia.nic.in
12. www.fssai.gov.in

Title: CELLS IN THEIR SOCIAL CONTEXT

Course: SMIC1003

LEARNING OBJECTIVES

1. Understand various aspects of cell communication
2. Understand cell division and cell death
3. Understand developmental biology and stem cells

Number of lectures: 60

UNIT 1: CELL COMMUNICATION

15 LECTURES

LEARNING OBJECTIVES

Understand principles of Cell communication

-
- 1. General Principles of cell communication** **2L**
 - Extracellular signal molecules
 - Intracellular signaling proteins
 - Classes of cell-surface receptor proteins

 - 2. Signaling through G-protein-coupled cell surface receptors** **5L**
 - G-protein relay signals
 - c-AMP and protein kinases
 - Inositol phospholipid signaling pathway
 - Intracellular mediators and their effects

 - 3. Signaling through enzyme coupled cell surface receptors** **6L**
 - Receptor Tyrosine Kinases
 - Ras
 - MAP kinase
 - PI-3 kinase
 - TGF
 - Bacterial chemotaxis

 - 4. Signaling in plants** **2L**
 - Receptor Serine / Threonine kinases
 - Role of ethylene
 - Phytochromes

UNIT 2: CELL CYCLE AND CELL DEATH

15 LECTURES

LEARNING OBJECTIVES

1. Understand the concepts of cell division and apoptosis

-
- 1. Mechanism of cell division** **9L**
 - Cell cycle and cell cycle control system
 - S-phase
 - Mitosis
 - Cytokinesis

- Control of cell division and cell growth
- Comparison with prokaryotes

2. Apoptosis

6L

- Programmed cell death
- Extrinsic pathway of apoptosis
- Intrinsic pathway of apoptosis

UNIT 3: STEM CELLS, GERM CELLS AND FERTILIZATION 15 LECTURES

LEARNING OBJECTIVES

1. Understand the types of stem cells and ethics involved in their use
2. Understand the gamete formation and fertilization in animals

1. Stem cells

7L

- Types of stem cells
 - i. Embryonic stem cells
 - ii. Adult stem cells
 - iii. Induced pluripotent stem cells
- Applications of stem cells in
 - i. Regenerative medicine
 - ii. Cancer therapy
- Ethical considerations of stem cell therapy

2. Germ cells and fertilization

8L

- Overview of sexual reproduction
- Meiosis
- Eggs
- Sperm
- Fertilization

UNIT 4: DEVELOPMENTAL BIOLOGY

15 LECTURES

LEARNING OBJECTIVES

1. Understand the types of stem cells and ethics involved in their use
2. Understand the development of multicellular organisms

1. Development of animals

10L

- Universal mechanisms of animal cell development
- Mechanisms of pattern formation
 - i. Axes development
 - ii. Role of egg polarity, gap, pair rule and *Hox* genes
- Developmental timing
 - i. MicroRNA,
 - ii. Environmental cues
 - iii. Role of hormones
- Morphogenesis
- Growth regulation during development
- *Caenorhabditis elegans* and *Drosophila* as model organisms

2. The genetics of flower development in *Arabidopsis* **2L**
3. Development in *Dictyostelium* **1L**
4. Programmed cell death in development **1L**
5. Evo-Devo: The study of evolution and development **1L**

CIA: Group Presentation, Test

References:-

Unit 1

1. Molecular Biology of the Cell, Albert B., Johnson A., Lewis J., Raff M., Roberts K. & Walter P., 5th ed, 2008, Garland Science, Taylor & Francis Group, NY, USA.
2. Molecular Cell Biology, Lodish H., Berk A., Kaiser C. A., Krieger M. Bretscher A., Ploegh H., Amon A. and Scott M., 7th Ed., 2013, W.H Freeman & Company, New York, USA.
3. Cell biology, Gerald Karp, 6th Ed., 2010, John Wiley & sons, USA.

Unit 2

1. Molecular Biology of the Cell, Albert B., Johnson A., Lewis J., Raff M., Roberts K. & Walter P., 5th ed, 2008, Garland Science, Taylor & Francis Group, NY, USA.
2. Molecular Biology of the Gene, Watson J. D., Baker T. A., Bell S. P., Gann A., Levine M., Losick R., 5th Ed., 2007, Pearson Education, UK.
3. Molecular Cell Biology, Lodish H., Berk A., Kaiser C. A., Krieger M. Bretscher A., Ploegh H., Amon A. and Scott M., 7th Ed., 2013, W.H Freeman & Company, New York, USA.
4. Cell biology, Gerald Karp, 6th Ed., 2010, John Wiley & Sons Inc., USA.

Unit 3

1. Cell biology, Gerald Karp, 6th Ed., 2010, John Wiley & Sons Inc., USA.
2. Molecular Biology of the Cell, Albert B., Johnson A., Lewis J., Raff M., Roberts K. & Walter P., 5th ed, 2008, Garland Science, Taylor & Francis Group, NY, USA.

Unit 4

1. <http://dictybase.org/> - Online resource for Dictyostelium development.
2. <https://dev.biologists.org/> - Online resource for Developmental biology.
3. <https://flybase.org/> - Online resource for Developmental biology in Drosophila.
4. Insights into morphogenesis from a simple developmental system. Chisholm, R.L. & Firtel, R.A. Nat. Rev. Mol. Cell Biol. 5, 531–541 (2004).
5. Molecular Biology of the Cell, Albert B., Johnson A., Lewis J., Raff M., Roberts K. & Walter P., 6th ed, 2014, Garland Science, Taylor & Francis Group, NY, USA.
6. Principles of Genetics, D. Peter Snustad & Michael J. Simmons, 6th Ed., 2012, John Wiley & Sons Inc., USA.

Title: ADVANCES IN BIOTECHNOLOGY

Course: SMIC1004

LEARNING OBJECTIVES

Know the applications and advances in the field of animal, plant, molecular and nano biotechnology.

Number of lectures: 60

UNIT 1: ANIMAL BIOTECHNOLOGY

15 LECTURES

LEARNING OBJECTIVES

1. Know the concept and techniques in animal tissue culture.
2. Understand generation and applications of transgenic animals.

1. Animal Tissue Culture	2L
• Primary culture, Organ culture, Embryo Culture, Established Cell lines	
2. Scale up, cryopreservation	2L
3. Risks and Safety associated with animal tissue culture	2L
4. Stem cell culture and applications	2L
5. Methods of generation of transgenic animals and their application	7L
• Retroviral method	
• DNA microinjection method	
• Engineered embryonic stem cell method	
• Transgenic cattle, transgenic birds, transgenic fish	

UNIT 2: PLANT AND AGRICULTURAL BIOTECHNOLOGY

15 LECTURES

LEARNING OBJECTIVES

1. Understand advanced technologies involved in plant biotechnology.
2. Understand applications of transgenic plants.

1. Plant Transformation Technology	7L
• <i>Agrobacterium</i> mediated gene transfer, <i>Agrobacterium</i> based vectors, viral vectors	
• Direct gene transfer methods, chemical methods, electroporation, microinjection, particle bombardment, molecular breeding, plant selectable markers, reporter genes, positive selection, selectable marker elimination	
• Transgene silencing, strategies to avoid transgene silencing	
2. Plant Genetic Engineering for Productivity and Performance	8L
• Biotic Stress Tolerance- Herbicide resistance, Glyphosate, Insect Resistance, <i>Bt</i> toxin, Disease Resistance, Virus resistance	
• Abiotic Stress Tolerance-- drought, flood, salt and temperature.	
• Manipulation of photosynthesis, nitrogen fixation, nutrient uptake efficiency	

- Quality Improvement-protein, lipids, carbohydrates, vitamins and minerals.
- Biosafety concerns of transgenic plants
- Plants as bioreactor

UNIT 3: PLANT TISSUE CULTURE & NANOBIO TECHNOLOGY

15 LECTURES

LEARNING OBJECTIVES

1. Know the concept and techniques in plant tissue culture.
2. Understand synthesis and properties of nanostructures and their applications.

1. Plant Tissue Culture for crop improvement 5L

- Initiation and maintenance of callus and suspension culture, direct and indirect organogenesis, Micropropagation, artificial seeds, anther culture and dihaploids, Protoplast isolation culture and fusion, production of haploids, somaclonal variations, Germplasm conservation, Somatic hybrids

2. Production of secondary metabolites from plant cell cultures 2L

- Technology of plant cell culture for production of chemicals
- Bioreactor systems and models for mass cultivation of plant cells

3. Nanoscale systems and Synthesis of nanostructures 3L

- Nanoparticles, nanowires, thin films and multilayers
- Physical, chemical and biological methods

4. Nano-biosensors 1L

- Cantilevers: types and applications
- Electrochemical nanosensors

5. Manipulation of biomolecules using nanotechnology 2L

- Optical tweezers
- Dielectrophoresis
- Micro and Nanofluidics
- Chip technologies

6. Medical nanotechnology 2L

- Drug and gene delivery systems
- Nanoimaging
- Nanomedicine and cancer diagnostics and treatment.

UNIT 4: ADVANCES IN MOLECULAR BIOTECHNOLOGY

15 LECTURES

LEARNING OBJECTIVES:

Learn the different methodologies involved in molecular biotechnology

1. Chemical synthesis, sequencing of DNA and synthetic biology 3L

- Phosphoramidite method for nucleotide synthesis, uses of synthesized oligonucleotides, Dideoxynucleotide method for sequencing of DNA, Automated DNA sequencing, Next generation sequencing

- **Synthetic Biology:** Introduction, types, mechanisms, applications in industry

2. Manipulation of Gene Expression in Prokaryotes **3L**

- Gene expression from strong and regulatable promoters, fusion proteins, unidirectional tandem gene arrays, increasing protein stability, protein folding, DNA integration into host chromosome

3. Heterologous protein production in eukaryotic cells **3L**

- Expression systems like *Saccharomyces cerevisiae*, *Pichia pastoris*, Baculovirus-Insect cell, mammalian cell

4. Protein Engineering **6L**

- Adding disulfide bonds, changing asparagine to other amino acids, Reducing the number of free sulfhydryl residues, increasing enzymatic activity, modifying metal cofactor requirement, decreasing protease sensitivity, modifying protein specificity, increasing enzyme stability and specificity
- Cre-lox system and CRISPR-Cas9 for gene modification
- Synthesis of commercial products by recombinant microorganisms

CIA: Test, Assignment

References:-

Unit 1:

1. Animal Cell Culture, Gangal S., 2010, Universities press, India.
2. Basic Cell Culture, Davis J. M., 2nd Ed., 2007, Oxford press, UK.
3. Culture of Animal Cells, Freshney I., 2011, John Wiley and Sons Inc., USA.
4. Molecular Biotechnology, Principles and Applications of recombinant DNA, Glick and Paternak, 4th Ed., 2010, ASM Press.

Unit 2:

1. H. K. Das, Textbook of Biotechnology, 2004, Wiley India, India.
2. Introduction to Plant Biotechnology, H.S. Chawla, 3rd Ed., 2002, Oxford and IBH publishers, UK.
3. Molecular Biotechnology, Principles and Applications of recombinant DNA, Glick and Paternak, 4th Ed., 2010, ASM Press, USA.
4. Plant Biotechnology: The genetic manipulation of plants, 2005, A. Slater, N. Scott & M. Fowler, Oxford Univ Press, Oxford, UK.

Unit 3:

1. An introduction to Plant Tissue Culture, Kalyan Kumar De, 1992, New Central Book Agency, India.
2. Biotechnology, B. D. Singh, 2010, Kalyani Publishers, India.
3. Fundamentals of Nanotechnology, Hornyak D., Moore J., Tibbals H., Dutta J., 2008, CRC press, USA.
4. Handbook of Nanostructured biomaterials and their applications in nanobiotechnology, Nalwa H. S., 2005, American Scientific Publishers, USA.
5. Introduction to plant tissue culture, Razdan M. K., 2003, Science Publishers, USA.

6. Nanobiotechnology, Niemeyer C. M. and Mirkin C. A., 2005, Wiley-Interscience, USA.
7. Nanotechnology: principles and practices Kulkarni, S. K. (2014). Springer, USA.

Unit 4:

1. An Introduction to Molecular Biotechnology: Molecular Fundamentals, Methods and Applications in Modern Biotechnology, edited by Wink M., 2006, Wiley VCH, USA.
2. Molecular Biotechnology, Principles and Applications of recombinant DNA, Glick and Paternak, 4th Ed., 2010, ASM Press, USA.
3. Molecular biotechnology: Principles and practices, Channarayappa, 2006, Universities Press, India.
4. Synthetic Biology, Benner S., Sismour A. M., 2005, Nature Reviews Genetics, v6, p533 -543.

M.Sc. II
Practicals semester 4

Course: SMIC10PR

INTERNAL PROJECT

SMIC 1001PR and SMIC 1002PR

Group based Research Projects to study industrially/environmentally important microbes/microbial processes using microbial diverse rich samples.

FOOD, PHARMACEUTICAL AND COSMETIC MICROBIOLOGY

SMIC 1003PR

Food Microbiology

1. Microbiological study of fermented food: Idli batter
2. Quality Assessment and Analysis of packaged foods: Salad, Juice, Milk, Yogurt (ISI standards)
3. Microbiological analysis of fish samples with respect to sample processing for recovery and detection of EPEC, *Salmonella*, *Vibrio* as per BIS/ISO/APHA standards and computation of measure of uncertainty.

Pharmaceutical and Cosmetic Microbiology

1. Sterility testing of pharmaceutical product (eg: water for injection) and reporting
2. Microbial load of cosmetic product
3. Efficacy testing of preservatives from cosmetics shelf life study (used and unused products)

ENVIRONMENTAL MICROBIOLOGY, ANIMAL TISSUE CULTURE AND NANOTECHNOLOGY

SMIC 1004PR

Environmental Microbiology

1. Soil analysis- nitrogen, phosphorus, chloride, organic matter, & calcium carbonate content.
2. Biofilm visualization by staining of a slide immersed in soil (to emphasize compositional and structural variations in biofilms from different environment).
3. Determination of MIC of antimicrobials with sessile and planktonic bacteria (to show higher resistance of biofilms to antimicrobials as compared to planktonic cells) quantified using crystal violet assay
4. Analysis of sludge: sewage and industrial for the following parameters: sludge volume index (SVI), Mixed liquor suspended solids (MLSS), Mixed liquor volatile suspended solids (MLVSS), F/M ratio.

Advances in Biotechnology

1. Terminology, Laboratory design of Animal tissue culture laboratory
2. Preparation of complete medium, Sterilization and sterility checking.
3. Chick embryo fibroblast culture, viable staining with haemocytometer
4. Basic techniques in Animal tissue culture: Revival, Subculturing, Cytotoxicity and Freezing
5. Preparation of Nanosilver By Wet reduction Method (Chemical), using plant extracts(plants) & microorganisms
6. Characterisation of Nanosilver by UV spectrometry methods
7. Antimicrobial effect of Ionic silver and Nanosilver prepared by above methods.
8. Study of Nanosilver coated Gauze/textiles for antimicrobial effect on different bacteria

CIA:

SMIC 1001PR: Project Conduct

SMIC 1002PR: Rough draft of internal Project Report

SMIC 1003PR: Lab experiment

SMIC 1004PR: Lab experiment