



Syllabus

First Semester Courses in MSc (MICROBIOLOGY)

2023-2024

Contents:

- **Syllabus for Core Courses:**
 - PSMIC6001CR1 Molecular Genetics
 - PSMIC6002CR1 Microbial Biochemistry
 - PSMIC6003CR1 Advances in Immunology
- Evaluation and Assessment guidelines



APPROVED SYLLABUS

Hinde
PRINCIPAL
ST. XAVIER'S COLLEGE
AUTONOMOUS
MUMBAI - 400 001.

M.Sc. Part 1, Sem 1 MICROBIOLOGY

Course code: PSMIC6001CR1

TITLE: MOLECULAR GENETICS

Credits 4 - Theory 3 (Total 45 hr) and Practical 1 (Total 30 hr)

Course Objectives:

- Explore the events of DNA replication, transcription and translation
- Describe molecular mechanisms involved in recombination, mutation and repair and regulation of gene expression in bacteria and eukaryotes
- Discuss the mechanisms of regulation of gene expression in eukaryotes and prokaryotes
- Study the genetic basis of cancer

Number of lectures: 45

Course Outcomes (COs):

- Compare gene expression and regulation in prokaryotes and eukaryotes
- Critique experimental proof of gene expression and regulation
- Solve applied problems in mutagenesis, develop critical thinking skills
- Distinguish between different mechanisms of DNA repair
- Illustrate differences between cut and paste type of transposons and replicative transposons and trace the genetic and evolutionary significance of transposable elements
- Relate genetic pathways to cancer and describe experiments to prove the genetic basis of cancer

Unit 1: Molecular mechanisms of replication, recombination, and mutation (15 lectures)

- 1. DNA replication** 4L
 - Replication in eukaryotic and prokaryotic cells
 - Experimental evidences supporting DNA replication
- 2. Mutations** 8L
 - Molecular basis of mutation-problem solving in mutations induced by chemicals, radiation and transposable genetic elements;
 - Expanding trinucleotide repeats and inherited human diseases
- 3. Recombination** 3L
 - Homologous recombination in eukaryotes
 - Mating type switch



Unit 2: Gene expression and its regulation

(15 lectures)

1. Gene expression in eukaryotes

9L

a. Transcription

- Experimental evidences supporting different stages of 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

b. Translation

- Experimental evidences to explain the mechanism of translation
- mRNA surveillance, Nonsense mediated mRNA decay
- Post translational modification of proteins

2. Regulation of gene expression

6L

- Genes and regulatory element- DNA binding proteins
- Regulation through transcriptional activators, Co-activators and repressors, enhancers and insulators
- Operons
- Regulation through RNA interference
- Regulation through RNA processing and degradation
- Riboswitches

Unit 3: Transposons, DNA repair and cancer genetics

(15 lectures)

1. Transposons

4L

- 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

2. DNA repair mechanisms

5L

- 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

3. Genetic basis of cancer

6L

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- 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

List of Recommended Reference Books

Unit 1

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

Unit 2

1. Molecular Cell Biology - Lodish, H; Berk, A.;Kaiser,C.A. Krieger, M.; Scott, M.; Bretscher, A; Ploegh, H.; and Matsudaira, P; 8th ed., 2016 ,W.H Freeman and Company
2. Genetics: A Conceptual Approach, Benjamin Pierce 5th ed., 2013, W. H. Freeman and Co
3. Molecular Biology, R. F. Weaver, 5th ed., 2011 McGraw-Hill
4. Genes X, Lewin B., 2008, Jones and Bartlett Publishers

Unit 3

1. 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
2. The Biology of Cancer, Weinberg, R., 2nd ed., 2013, Garland science.
3. Principles of Genetics, Snustad and Simmons, 6th ed., 2012, John Wiley and Sons Inc
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

PRACTICAL

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Details of practical sessions:

1. Working in the microbiology laboratory- biosafety and standard operating procedures
2. Isolation of streptomycin resistant *Escherichia coli* using a chemical mutagen
3. Inducing reverse mutation in *Escherichia coli* auxotrophs by UV-mutagenesis
4. Isolation of specific mutants by penicillin enrichment technique
5. Study of genetic exchange in bacteria- Conjugation
6. Problems on gene transfer mechanisms

Evaluation (Theory): Total marks – 100

- I. Formative Assessment 'for' Learning (continuous internal assessment - CIA to improve learning).
CIA – 40 marks
CIA 1: Test – 20 marks
CIA 2: Written assignment – 20 marks

- II. Summative Assessment 'of' Learning (focus on outcomes, quantitative data for outcomes of instruction).
End Semester Examination – 60 marks
One question from each unit for 20 marks, with internal choice. Total marks per question with choice – 25-30 marks

Evaluation (Practical): Total marks – 50

- CIA: 20 marks
End Semester Practical Examination – 30 marks

Template for the End Semester examination

UNITS	KNOWLEDG E	UNDERSTANDIN G	APPLICATION and ANALYSES	TOTAL MARKS- Per unit
1	6	6	8	20
2	6	6	8	20
3	6	6	8	20
- TOTAL - Per objective	18	18	24	60
% WEIGHTAGE	30%	30%	40%	100%



M.Sc. Part 1, Sem 1 MICROBIOLOGY

Course code: PSMIC6002CRI

TITLE: MICROBIAL BIOCHEMISTRY

Credits 4 - Theory 3 (Total 45 hr) and Practical 1 (Total 30 hr)

Course Objectives:

- Relate the structural details of organic macromolecules to their biological functions
- Review protein structures and folding
- Appraise the unique processes of cellular export, photosynthesis and biological nitrogen fixation in bacteria
- Critique signaling systems, stress responses and quorum sensing in bacteria

Number of lectures: 45

Course Outcomes (COs):

- Illustrate and sketch the structures and describe the molecular details and biological roles of macromolecules.
- Choose an appropriate method for primary amino acid sequencing and deduce the amino acid sequence from given experimental results.
- Compare the various secondary structures found in proteins with the help of examples and evaluate the roles of various factors in providing stability to these structures.
- Assess the diverse strategies used by microorganisms to convert N₂ to ammonia and phototrophically fix carbon with respect to energetic costs and physiological constraints
- Classify different secretion systems found in bacteria and correlate them to the pathogenesis displayed by the organisms.
- Relate structure and properties of the major components of key signal transduction pathways to processes such as cell differentiation and quorum sensing.

Unit 1: BIOLOGICAL MACROMOLECULES

(15 lectures)

1. Carbohydrates

2L

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

2. Lipids

2L

- Lipid classification
- Structure of lipids in membranes - glycerolipids, ether lipids, galactolipids, sulfolipids, lipids in Archaea
- Eukaryotic lipids- sphingolipids, terpenoids, isoprenoids
- Functions of lipids- signals, vitamins and cofactors, pigments

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- 3. Nucleic Acids** **2L**
- The factors that determine DNA structure- denaturation and melting curve, hydrogen bonds and hydrophobic interactions, base stacking, ionic strength.
 - Renaturation kinetics- C_{ot} 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.
- 4. Amino acids and Primary structure of Proteins** **2L**
- Classification and stereochemistry
 - Derivatives, ionization – titration curve.
 - Structure and stability of peptide bond
 - Protein sequencing
- 5. Secondary, Tertiary and Quaternary Structure of Proteins** **7L**
- 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 and domains
 - Thermodynamics of folding and protein stability- electrostatic forces, Van der Waals forces, hydrogen bonding forces, disulfide bonds,
 - Protein denaturation, stability of thermostable protein. chaperonins and prion proteins
 - Quaternary Structure- subunit interactions and symmetry in protein

Unit 2: Cellular export systems, bacterial photosynthesis and biological nitrogen fixation
(15 lectures)

- 1. Cellular export systems** **9L**
- Extracellular protein secretion
 - Drug export systems
- 2. Bacterial Photosynthesis** **3L**
- Phototropic bacterial families
 - Photosynthetic apparatus and its reactions
 - Carbon metabolism
- 3. Biological Nitrogen Fixation** **3L**
- Nitrogen fixing organisms
 - Biochemistry of nitrogen fixation
 - Regulation of nitrogenase



Unit 3: Signal transduction in bacteria

(15 lectures)

1. **General themes in bacterial signal transduction (introduction and basic principles)** 3L
 - One component signaling, Two component signaling, Quorum sensing, Global control networks

2. **Mechanisms of signal transduction** 12L
 - 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

List Of Recommended Reference Books

Unit 1

1. Lehninger Principles of Biochemistry, Nelson D.L., Cox M.M., 8th ed, 2021, Macmillan
2. Lehninger Principles of Biochemistry, Nelson D.L., Cox M.M., 7th ed, 2017, Macmillan.
3. Lehninger Principles of Biochemistry, Nelson D.L., Cox M.M., 6th ed, 2013, Macmillan publishers
4. Biochemistry, Voet D. and Voet J.G., 4th ed., 2011, John Willey and Sons Inc.
5. Principles of Biochemistry, Zubay, G., 4th ed., 1998, Wm. C. Brown Publishers

Unit 2

1. Brock Biology of Microorganisms, Michael Madigan, John Martinko, Kelly Bender, Daniel Buckley, David Stahl, 16th ed., 2021, Pearson
2. Brock Biology of Microorganisms, Michael Madigan, John Martinko, Kelly Bender, Daniel Buckley, David Stahl, 15th global ed., 2019, Pearson
3. The physiology and biochemistry of prokaryotes, White D., Drummond, T. J. and Fuqua C., 4th ed., 2012, Oxford University Press
4. Biochemistry, Voet D. and Voet J.G., 4th ed., 2011, John Willey and Sons Inc.
5. Bacterial Metabolism, Gottschalk, G., 2nd ed., 1986, Springer-Verlag

Unit 3

1. Brock Biology of Microorganisms, Michael Madigan, John Martinko, Kelly Bender, Daniel Buckley, David Stahl, 16th ed., 2021, Pearson



2. Brock Biology of Microorganisms, Michael Madigan, John Martinko, Kelly Bender, Daniel Buckley, David Stahl, 15th global ed., 2019, Pearson
 3. The physiology and biochemistry of prokaryotes, White D., Drummond, T. J. and Fuqua C., 4th ed., 2012, Oxford University Press
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PRACTICAL

Details of practical sessions:

1. Selection and adaptation of gas chromatography for the detection of fatty acids generated by the action of microbial enzymes
 2. Determination of the degree of unsaturation of fats and oils
 3. Isolation of reducing sugars from natural sources
 4. Selection and modification of a chemical assay for estimation of total sugars
 5. Determination of molar absorption coefficient (ϵ) of l-tyrosine
 6. Determination of the pKs and pI for an amino acid by titration method
 7. Determination of the isoelectric point of a protein
 8. Estimation of polyphenols by Folin-Denis method
 9. Adaptation of *E. coli* to anaerobiosis
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Evaluation (Theory): Total marks – 100

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Template for the End Semester examination

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3	6	6	8	20
- TOTAL - Per objective	18	18	24	60
% WEIGHTAGE	30%	30%	40%	100%



M.Sc. Part 1, Sem 1 MICROBIOLOGY

Course code: PSMIC6003CR1

TITLE: ADVANCES IN IMMUNOLOGY

Credits 4 - Theory 3 (Total 45 hr) and Practical 1 (Total 30 hr)

Course Objectives:

- Explore maturation and activation of T and B cells
- Review advances in innate immunity, immune tolerance and autoimmunity,
- Assess vaccine strategies and immune suppressive measures in transplantation immunology and immunodeficiency diseases
- Understand immunological basis of cancer

Number of lectures: 45

Course Outcomes (COs):

- Compare and contrast the development, maturation and activation of T and B cells and interpret experiments conducted to provide insights into these processes; analyze results of fluorescence-activated cell sorting experiments
- Evaluate strategies employed to design vaccines
- Summarize cellular innate immune responses and predict outcome of interaction between pathogen associated molecular pattern and several host receptors.
- Choose approaches to manipulate the immune response to improve graft acceptance
- Demonstrate the involvement of immune system in cancer and the process of immunoediting
- Elucidate mechanisms of failure in host defense leading to autoimmune disorders and immunodeficiency diseases

Unit 1: Adaptive immunity - T and B cell maturation and activation (15 lectures)

1. T and B cell development

8L

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

2. T and B cell activation and memory generation

5L

- T and B cell activation and differentiation
- T and B cell memory generation
- Classical experiments- study and evaluation



3. Use of Fluorescence-activated cell sorting in development and activation of lymphocytes **2L**

Unit 2: Immune system in health and disease **(15 lectures)**

1. Recent advances in Non-specific immunity **7L**

- 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. Advances in Immunization **4L**

- Overview
- Passive immunization and Antibody engineering
- Active Immunization
- Vaccine development with one example (Malaria/TB)
- Any one recent vaccine development

3. Transplantation and Transfusion Immunology **4L**

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

Unit 3: Failure of host defense mechanism **(15 lectures)**

1. Immunodeficiency diseases **5L**

- Primary immunodeficiency
- Defects in the complement system
- Treatment approaches for immunodeficiency
- Animal models of primary immunodeficiency
- Secondary immunodeficiency and AIDS



2. 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

3. Cancer immunology

5L

- The immune response to cancer
- Classical experiments- study and evaluation
- Cancer immunotherapy - use of monoclonal Abs, CAR T cells, cancer vaccines

List Of Recommended Reference Books

Unit 1, 2 and 3

1. Kuby immunology, Runte, F., Renner IV, P., & Hoppe, M. 8th ed., 2019, International Edition, W. H. Freeman, New York.
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. Kuby Immunology, Owen, J., Punt, J. and Stanford, S., 7th ed., 2013, International Edition, Macmillan Higher Education.
4. The Immune Response to Infection, Kauffman, S. H. E., Rouse B.T., and Sacks D.L., 2011, ASM Press, Washington, US
5. Immunology – Essential and Fundamental, Pathak, S. and Palan, U., 3rd ed., 2011, Capital publishing company.
6. Rosalind Rowland and Helen McShane, Tuberculosis vaccines in clinical trials, Expert Rev Vaccines, 2011 May; 10(5): 645–658
7. 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
8. Chen, Y.Z. and Dolin R., Novel HIV vaccine strategies: overview and perspective, 2013, Therapeutic Advances in Vaccines, (0)0-1-14
9. 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
10. Takeuchi, O. and Akira, S., Pattern recognition receptors and inflammation, 2010, Cell, 140: 805-820
11. Current published papers/ reviews



PRACTICAL

Details of practical sessions:

1. Separation of mononuclear cells from blood by Ficoll-hypaque density gradient centrifugation, counting of viable cells by trypan blue.
2. Differential count of blood cells
3. Study of virulence factors- phagocytosis and phagocytic index.
4. Horizontal electrophoresis of proteins in human serum
5. Immunoelectrophoresis
6. SRID: for detection of immune deficiency and complement deficiency.
7. Diagnosis of microbial infections using ELISA

Evaluation (Theory): Total marks – 100

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