UNIVERSITY OF CALCUTTA

Notification No. CSR/73/2024

It is notified for information of all concerned that in terms of the provisions of Section 54 of the Calcutta University Act, 1979, (as amended), and, in the exercise of her powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 11.09.2024 approved the complete syllabus of Molecular Biology (Three-year MDC & Minor) under CCF, under this University, as laid down in the accompanying pamphlet.

The above shall take effect from the Odd Semester Examinnations,2024 & onwards.

19/9/24

Prof.(Dr.) Debasis Das

Registrar

SENATE HOUSE

Kolkata-700073

19.09.2024

University of Calcutta

Syllabus for

B. Sc. (Multidisciplinary) Program in

Molecular Biology

Under

CURRICULUM AND CREDIT FRAMEWORK (CCF, 2022)

Submitted

by

The Under-Graduate Board of Studies in Molecular Biology

UGBoS (MLBG)

University of Calcutta

2024

Course outline and scope

Molecular biology is a fascinating area of knowledge that strives to explain in molecular detail how all life on Earth functions and because of its advanced scope, is of enormous scientific importance and practical utility. Unfortunately, because of the details involved, sometimes students lose the big picture and fall upon memorizing the facts.

This course has been designed to provide a simple overview of molecular biology without introducing too many details and with a stress on illustrating how it can solve real-life problems.

Molecular biology is inherently an interdisciplinary subject combining biochemical and molecular biophysics concepts and techniques. The basis of life is biological molecules and their interactions. After completing this course, the student will have a basic but thorough understanding of how proteins and enzymes function on the basis of their amino acid makeup, what is the importance of water for biomolecular and cellular functioning, and what are the functions of carbohydrates, lipids and membranes. The course will also explain the molecular basis of heritability, the concepts of genes and genomes, and how they are constructed from nucleic acids. Where appropriate, the course will also explain how these molecules function together at the cellular and organismic level.

Course Structure of Molecular Biology (MDC)

(The first six core courses of the full syllabus will be taught in the minor program)

Semester	Course code	Course name	Code (Theory) [3 credits/75 marks]	Code (Practical) [1 credit/25 marks]
I	MLBG-MD-CC-1	Cell Biology - Principles and Techniques	MLBG-MD-CC-1-Th	MLBG-MD-CC-1-Pr
II	MLBG-MD-CC-2	Biological Macromolecules	MLBG-MD-CC-2-Th	MLBG-MD-CC-2-Pr
III	MLBG-MD-CC-3	Enzymes, Metabolism and Bioenergetics	MLBG-MD-CC-3-Th	MLBG-MD-CC-3-Pr
IV	MLBG-MD-CC-4	Genes and Genomes	MLBG-MD-CC-4-Th	MLBG-MD-CC-4-Pr
IV	MLBG-MD-CC-5	Biology of Microbes	MLBG-MD-CC-5-Th	MLBG-MD-CC-5-Pr
V	MLBG-MD-CC-6	Bacterial Genetics and Recombinant DNA Technology	MLBG-MD-CC-6-Th	MLBG-MD-CC-6-Pr
V/VI	MLBG-MD-CC-7	Biophysical Processes and Techniques	MLBG-MD-CC-7-Th	MLBG-MD-CC-7-Pr
VI	MLBG-MD-CC-8	Cell to Cell Communication and Immunology	MLBG-MD-CC-8-Th	MLBG-MD-CC-8-Pr

Structure of Skill Enhancement Course in Molecular Biology for MDC

Semester	Course code	Course name	Code (Theory) [3 credits/75 marks	Code (Practical) [1 credit/25 marks]
I/II/III	MLBG-MD-SEC-1	Basics of Molecular Diagnostics	MLBG-MD-SEC-1-Th	MLBG-MD-SEC-1-Pr

Structure of Interdisciplinary Course in Molecular Biology for MDC

Semester	Course code	Course name	Code (Theory) [3 credits]
I/II/III	MLBG-MD-ID-1-Th	Biostatistics without fear	MLBG-MD-ID-1-Th

Structure of Minor Courses in Molecular Biology for Four years Course (Major)

Semester	Course code	Course name	Code (Theory) [3 credits/75 marks]	Code (Practical) [1 credit/25 marks]
I/III	MLBG-MD-MN-1	Cell Biology - Principles and Techniques	MLBG-MD-MN-1-Th	MLBG-MD-MN-1-Pr
II/IV	MLBG-MD-MN-2	Biological Macromolecules	MLBG-MD-MN-2-Th	MLBG-MD-MN-2-Pr
V	MLBG-MD-MN-3	Enzymes, Metabolism and Bioenergetics	MLBG-MD-MN-3-Th	MLBG-MD-MN-3-Pr
VI	MLBG-MD-MN-4	Genes and Genomes	MLBG-MD-MN-4-Th	MLBG-MD-MN-4-Pr

Detailed syllabus

MLBG-MD-CC-1/MLBG-MD-MN-1

Cell Biology - Principles and Techniques (3 + 1 = 4 credits)

Learning objectives

After attending this course, the student should be able to

1. identify cells as the basic unit of life
2. explain the composition of essential structures found in prokaryotic and eukaryotic cells and describe their functions
3. explain the construction of a virus particle
4. explain the importance of water for physiological processes and the concept of a buffer
5. tell about the various types of interactions governing physiological processes
6. explain the functioning principles of light and electron microscopes

MLBG-MD-CC-1-Th/MLBG-MD-MN-1-Th

Cell Biology - Principles and Techniques (Theory) (3 credits)

Unit 1: Domains of life. Biology of cells (20 hours)

Cells as basic functional unit of life, cellular classification (three domains, i.e. eubacteria, archaebacteria, eukaryotes) (1 hr)

Prokaryotic cell organization: Prokaryotic cell structure, bacterial cell walls (2 hrs)

Eukaryotic cell organization: Brief idea of structure and function of plasma membrane, nucleus, endoplasmic reticulum, golgi apparatus, mitochondria, chloroplast, lysosome, peroxisome, cytoskeleton, cytosol, plant cell wall, plant cell vacuole. (6 hrs)

Viruses: range of sizes, constitution, organization (1 hr)

Brief idea of cell cycle (mitosis and meiosis) (2 hrs)

Unit 2: Molecules, minerals and water (5 hrs)

Importance of the carbon molecule (valency, chiral carbon, types of isomer) (2hrs)

Structure of water, Henderson-Hasselbalch equation and its significance, concept of pH / pKa, isoelectric pH (pI) and buffers. (5hrs)

Unit 3: Microscopy techniques (20 hours)

Optical microscopy, the nature of light—its particle and wave character. Ray diagrams and image formation.(4 hours)

Simple and compound microscopes, Applications of optical microscopes, Numerical Aperture (NA) Resolution, Contrast, depth of field and depth of focus, Angular magnification, Spherical aberration, Chromatic aberration of optical system (definitions only). Mathematical expression for limit of resolution in terms of Rayleigh criteria. Empty magnification.(6 hours)

Basic principles of oil immersion microscope. Limitations of optical microscopes.(2 hours)

Electron microscopy---basic working principle, advantages of electron microscope over optical microscope, Optical Microscopy vs. TEM, Electrostatic and magnetostatic electron microscopes, Relation between the applied voltage and wavelength of electrons.(6 hours)

MLBG-MD-CC-1-Pr/MLBG-MD-MN-1-Pr

Cell Biology - Principles and Techniques (Practical) (1 credit/25 marks)

1. Determination of refractive index of a given biological sample by traveling microscope

2. Determination of relative sizes of nucleus and cytoplasm of squamous cells

3. Preparation of phosphate buffer and measurement of pH

4. Negative staining of bacteria using nigrosin

Suggested reading

1. De Robertis, EDP and De Robertis EMF. (2006) Cell and Molecular Biology. 8th edition. Lipincott Williams and Wilkins, Philadelphia.
2. Cooper, GM and Hausman, RE (2009). The Cell: A Molecular Approach. 5th Edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
3. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W.H.Freeman
4. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company
5. Voet D and Voet JG (2004) Biochemistry 3rd edition, John Wiley and Son
6. Sharma VK (1991) Techniques in microscopy and cell biology. Tata McGraw Hill
7. Reimer L and Kohl H (2008) Transmission Electron Microscopy. Springer.

MLBG-MD-CC-2/MLBG-MD-MN-2

Biological Macromolecules (3 + 1 = 4 credits)

Learning objectives

After attending this course, the student should be able to

1. describe the structures and the chemical properties of the 20 amino acids.
2. describe the structure and the chemical properties of carbohydrates, lipids and nucleic acids (RNA and DNA).
3. describe the four levels of protein structure and explain how protein structure is influenced by the amino acid sequence.

MLBG-MD-CC-2-Th/MLBG-MD-MN-2-Th

Biological Macromolecules (Theory) (3 credits)

Unit 1: Molecular building blocks (16 hours)

Concept of intra- and intermolecular interaction (covalent bond, ionic bond, hydrogen bond, hydrophobic interaction, van der Waals interaction, coulomb interaction). Role of weak forces in biology. (8 hrs)

Carbohydrate: Structure, function and properties of monosaccharides (hexoses and pentoses), disaccharides (sucrose, lactose, maltose). (4 hrs)

Lipids: Definition and classification of lipids, structure and function of fatty acids, storage lipids, structural lipids. (4 hrs)

Amino acids: structure of twenty amino acids, classification, titration curve of amino acids, concept of zwitterionic structure, physical and chemical properties. (6 hours)

Nucleic acids: Ribonucleic and deoxyribonucleic acids, purines and pyrimidines, nucleosides and nucleotides. (2 hrs)

Unit 2: Proteins and nucleic acids (16 hours)

Proteins: classification of proteins on the basis of composition, conformation and function, different level of structural organization of proteins (primary, secondary, tertiary & quaternary), forces stabilizing protein structure and shape, physical and chemical properties. Domains and motifs (10 hours)

Nucleic acids: Secondary structure of nucleic acids. Watson and Crick model, A and B forms, Supercoiled and relaxed DNA. (6 hrs)

Unit 3: Polysaccharides and membranes (13 hours)

Storage and structural polysaccharides (glycogen, starch and cellulose). (6 hrs)

Roles of lipids in membrane structure. Fluid mosaic model of membrane structure. (7 hrs)

MLBG-MD-CC-2-Pr/MLBG-MD-MN-2-Pr

Biological Macromolecules (1 credits/25 marks)

1. Qualitative tests for amino acids and proteins.
2. Qualitative tests for reducing and non-reducing sugars, polysaccharides, lipids.
3. Identification of unknown compounds (from sugars, polysaccharides, lipids, amino acids and proteins).

Suggested reading

1. Sharma, DK (2013) Biochemistry. Narosa Publishing House
2. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company
3. Voet, D and Voet JG (2004) Biochemistry 3rd edition, John Wiley and Sons.
4. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W. H. Freeman

MLBG-MD-CC-3/MLBG-MD-MN-3

Enzymes, Metabolism and Bioenergetics (3+1 credits)

Learning objectives

After attending this course, the student should be able to

1. gain knowledge about different enzymes and their significance,
2. correlate how a living organism exchanges energy and matter with the surroundings for its survival, and store free energy in the form of energy-rich compounds,
3. recognize how the catabolic breakdown of the substances is associated with release of free energy; whereas, free energy is utilized during synthesis of biomolecules i.e., anabolic pathways,
4. apply the knowledge of metabolic pathways to get insight about disease diagnostics, treatment and drug development.

MLBG-MD-CC-3-Th/MLBG-MD-MN-3-Th

Enzymes, Metabolism and Bioenergetics (Theory) (3 credits/75 mark)

Unit I - Enzymes (15 hours)

General properties, nomenclature and classification (IUBMB Classification of enzymes, two examples of each class with reaction) , holoenzyme, apoenzyme, cofactors, coenzyme, prosthetic groups.

Activation energy and transition state, energy profile diagram for uncatalyzed and enzyme-catalyzed reactions, enzyme activity, enzyme units (International Unit and SI unit), specific activity, turnover number, concept of active sites, Fischer's lock and keyhypothesis, Koshland's induced fit hypothesis.

Kinetics of enzyme catalysed reactions - Michaelis-Menten equation, Lineweaver-Burk plot, determination of K_m and V_{max}, significance of K_m and V_{max}.

Factors influencing enzyme reactions (substrate concentration, enzyme concentration, pH, temperature, time, metal ions on the activity of enzyme and enzyme inhibition (competitive, noncompetitive and uncompetitive inhibitors, effect of each inhibitor on K_m and V_{max} values).

Preliminary concept of allosteric enzymes.

Isoenzymes - detection, characterization and significance.

Unit II - Bioenergetics (10 hours)

First and second laws of Thermodynamics. Definitions of Gibb's Free Energy, enthalpy, and entropy and mathematical relationship among them, Standard free energy change and equilibrium constant, redox potential, high energy compounds.

Unit III - Metabolism of Biomolecules (20 hours)

Glycolysis – biochemical steps involved in glycolytic pathway,

Fate of pyruvate under aerobic and anaerobic condition, TCA cycle and their regulatory mechanisms. electron transport chain, oxidative phosphorylation, role of inhibitors and uncouplers.

Basic concepts of Glycogenesis, Glycogenolysis, Gluconeogenesis, Pentose phosphate pathway

Basics of fat and protein metabolism.

MLBG-MD-CC-3-Pr/MLBG-MD-MN-3-Pr

Enzymes, Metabolism and Bioenergetics (Practical) (1 credit/ 25 Marks)

1. Assay of enzyme activity and specific activity of alkaline phosphatase.
2. Colorimetric study of activity of amylase.
3. Determination of K_m and V_{max} using Lineweaver-Burk plot.

Suggested reading

1. Sharma, DK (2013) Biochemistry. Narosa Publishing House
2. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company
3. Voet, D and Voet JG (2004) Biochemistry 3rd edition, John Wiley and Sons.
4. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W. H. Freeman
5. Varley H. (1976) Practical Clinical Biochemistry. Heinemann Medical Books

MLBG-MD-CC-4/MLBG-MD-MN-4

Genes and Genomes (3+1 credits)

Learning objectives

After attending this course, the student should be able to

1. comprehend the fundamental tenets of molecular biology,
2. answer how hereditary information is propagated,
3. understand how genetic information is decoded,
4. gain insight about how proteins are synthesized within a cell.

MLBG-MD-CC-4-Th/MLBG-MD-MN-4-Th

Genes and Genomes (Theory) (3 credits/75 marks)

Unit I : Propagation of Genetic Information (20 hours)

Concept of central dogma. Recapitulation of DNA structure in brief.

Features of DNA Replication in prokaryotes. Components of replication machinery: DNA polymerase, primase, topoisomerase.

Proof of semiconservative nature of DNA replication.

Features and mechanism of bidirectional DNA replication.

Unit II: Transcription in Prokaryotes (15 hours)

Gene expression. RNA structure and types of RNA, transcription in prokaryotes with E. Coli as model system: Prokaryotic RNA polymerase, role of sigma factor, promoter.

Mechanism of transcription in prokaryotes: Initiation, elongation and termination of RNA chains.

Regulation of gene expression in bacteria. Principles of gene regulation, negative and positive regulation. Preliminary concept of lac and trp operons.

Unit III: Translation in Prokaryotes (10 hours)

Genetic code, properties of genetic code, wobble hypothesis.

Components of Protein synthesis machinery: Messenger RNA, tRNA structure and function.

Charging of tRNA, aminoacyl tRNA synthetases, ribosome structure and assembly.

Mechanism of protein synthesis in prokaryotes: initiation, elongation and termination.

MLBG-MD-CC-4-Pr/MLBG-MD-MN-4-Pr

Genes and Genomes (Practical) (1 credit/25 marks)

1. Wavelength scan of DNA (220 to 320 nm)
2. Checking the purity of DNA samples by measuring A260/280 ratio.
3. Spectrophotometric determination of concentration of DNA.
4. Colorimetric estimation of protein by Lowry's method

Suggested reading

1. Watson J. et al. (2013) Molecular Biology of the Gene. Pearson.
2. Bergtrom G. (2023) Cell and Molecular Biology: What We Know & How We Found Out. 5th edition. University of Wisconsin.

MLBG-MD- CC-5

Biology of Microbes (3+1 credits)

Learning objectives

After attending this course, the student should be able to

1. define and classify different types of microorganisms (e.g., bacteria, viruses, fungi, protozoa),
2. explain the basic structure and function of microbial cells,
3. describe the metabolic processes of microorganisms, including growth, reproduction, and energy production.
4. perform basic microbiological techniques, such as culturing, staining, and identification of microorganisms,
5. interpret the results of microbiological experiments and tests.

MLBG- MD- CC-5-Th

Biology of Microbes (Theory) (3 credits/75 marks)

Unit I : Diversity of Microorganisms (15 hrs)

Systems of classification, binomial nomenclature, Whittaker's five kingdoms and Carl Woese's three kingdom classification systems and their utility.

General characteristics of different groups; Acellular microorganisms (Viruses, Viroids, Prions) and Cellular microorganisms (Prokarya: Archaea and Bacteria, Eukarya: Algae, Fungi and Protozoa) giving definitions and citing examples.

Unit II : Bacterial Cell Organization (15 hrs)

Cell size, shape and arrangement, capsule, flagella, and pili.

Cell wall: Composition of Gram-positive and Gram-negative cell walls and archaebacterial cell wall, Gram and acid-fast staining mechanisms, lipopolysaccharide (LPS), spheroplasts, protoplasts.

Effect of antibiotics and enzymes on the cell wall.

Cell Membrane: chemical composition of bacterial and archaeal cell membranes.

Endospore: Structure, formation, stages of sporulation.

Unit III : Microbial Growth and Nutrition (10 hrs)

Nutritional requirements in bacteria and nutritional categories; Culture media: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media.

Asexual methods of reproduction, growth curve of bacteria, phases of growth, calculation of generation time, and specific growth.

Overview of bacterial reproduction: Transformation, transduction and conjugation. Endospores and sporulation in bacteria.

Unit IV: Overview of Viruses (5 hrs)

Discovery of viruses, nature and definition of viruses, general properties,

Structure of Viruses: enveloped and non-enveloped viruses. Viruses, viroids and prions

MLBG-MD-CC-5-Pr

Biology of Microbes (Practical) (1 credit/25 marks)

1. Isolation technique of single colony of bacteria from pure cultures by the streak plate and spread plate methods.

2. Preparation of nutrient Agar media/broth and establishment of aseptic culture of bacteria.

3. Bacterial growth curve.

4. Gram staining of bacteria.

Suggested reading

1. Alexopoulos CJ, Mims CW, and Blackwell M. (1996). Introductory Mycology. 4th edition. John Wiley and Sons, Inc.
2. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.
3. Kumar HD. (1990). Introductory Phycology. 2nd edition.Affiliated East Western Press.
4. Madigan MT, Martinko JM and Parker J. (2009). Brock Biology of Microorganisms. 12th edition. Pearson/Benjamin Cummings.
5. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.
6. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008) Microbiology: An Introduction. 9 th edition. Pearson Education.
8. Willey JM, Sherwood LM, and Woolverton CJ. (2008) Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education

MLBG- MD- CC-6

Bacterial Genetics and Recombinant DNA Technology (3+1 credits)

Learning objectives

After attending this course, the student should be able to

1. understand the concepts of molecular cloning,

2. acquire basic knowledge on DNA manipulation using restriction and modification enzymes,

3. get an idea about the synthesis of cDNA,

4. gain knowledge on different methods used for gene cloning,

5. get acquainted with the principles and applications of different PCR techniques including Real Time PCR,

6. acquire knowledge on the genome organization of prokaryotes and extrachromosomal elements,

7. gain insight into the mechanisms of genetic recombination in bacteria.

MLBG-MD-CC-6-Th

Bacterial Genetics and Recombinant DNA Technology (Theory) (3 credits/75 marks)

Unit I - Bacterial Genetics (15 hours)

Genome organisation in bacteria, extrachromosomal inheritance, plasmids and episomes, incompatibility groups of plasmids, plasmid copy number and curing of plasmids.

Mechanisms of horizontal gene transfer in bacteria; Transformation - discovery, mechanism of natural competence; Conjugation - discovery, mechanism, Hfr and $F^{/}$ strains; Transduction - generalized transduction and specialized transduction.

Unit II - Recombinant DNA Technology (30 hours)

Restriction modification systems in bacteria, different types of restriction enzymes, nomenclature, recognition sequences, cohesive and blunt ends.

Applications in molecular cloning, restriction mapping, restriction fragment length polymorphism (RFLP). T4 and *E. coli* DNA Ligases, use of linkers and adaptors.

Cloning Vectors: pBR and pUC vectors, bacteriophage lambda, BACs.

Expression vectors: *E. coli* lac and T7 promoter-based vectors, shuttle vectors, Ti plasmid.

DNA modifying enzymes and their applications: DNA polymerases, terminal deoxynucleotidyl transferase, kinases and phosphatases.

Introduction of DNA into host cells: Artificial transformation of E.coli, electroporation.

Gene cloning strategies: cDNA synthesis and cloning.

Methods used for Gene Cloning: Basics of Polymerase Chain Reaction, RT-PCR, Real-Time PCR, applications of PCR techniques, agarose gel electrophoresis of DNA, blotting techniques.

MLBG-MD-CC-6-Pr

Bacterial Genetics and Recombinant DNA Technology (Practical) (1 credit/ 25 Marks)

1. Isolation of plasmid DNA and Agarose Gel Electrophoresis.
2. Preparation of competent cells by calcium chloride method and transformation of *E. coli* host with plasmid DNA.
3. Digestion of plasmid DNA using restriction enzymes and analysis by agarose gel electrophoresis.

Suggested reading

1. Brown TA. (2010) Gene Cloning and DNA Analysis. 6th edition. Blackwell Publishing, Oxford, U.K.
2. Primrose SB and Twyman RM. (2006) Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
3. Sambrook J and Russell D. (2001) Molecular Cloning-A Laboratory Manual. 3rd edition. Cold Spring Harbor Laboratory Press.
4. Gardner EJ, Simmons MJ, Snustad DP (2008) Principles of Genetics. 8th Ed. Wiley India.
5. Russell PJ. (2009) Genetics - A Molecular Approach. 3rd Ed, Benjamin Cummings.
6. Maloy SR, Cronan JE and Freifelder D (2004) Microbial Genetics. 2nd ed., Jones and Bartlett Publishers.

MLBG- MD-CC-7

Biophysical Processes and Techniques (3+1 credits)

Learning objectives

After attending this course, the student should be able to

1. theoretically describe the fundamental principles of diffusion, osmosis and viscosity,
2. understand basic spectroscopic techniques,
3. understand the principles of centrifugation, chromatography, electrophoresis,
4. carry out basic experiments on biomolecular properties, separation and spectroscopy

MLBG- MD- CC-7-Th

Biophysical Processes and Techniques (Theory) (3 credits/75 marks)

Unit 1 : Biophysical Processes (20 hours)

Diffusion: Dalton's law of partial pressure. Diffusion in fluids, Fick's laws (statement and explanation), facilitated diffusion, e.g. gas exchanges in lungs.

Osmosis: Definition, tonicity and isotonic solutions. Effect of tonicity on R.B.C. Cell nutrition. Brief introduction to dialysis.

Viscosity: Definition, laminar and turbulent flow, concept of Reynold's number, Newton's law of viscosity, coefficient of viscosity, relative viscosity .

Measurement by Ostwald's viscometer. Dependence of viscosity on temperature and other factors, e.g. size and shape of solutes (general idea), viscosity of human blood (general idea).

Unit II : Biophysical techniques (20 hours)

Centrifugation: Principles of sedimentation, preparative and analytical centrifugation, relative centrifugal force (RCF), sedimentation rate, sedimentation coefficient, factors affecting sedimentation velocity and sedimentation coefficient, determination of molecular weight

from sedimentation, differential centrifugation, isopycnic (equilibrium) sedimentation, (discussion with examples, e.g. Meselson and Stahl experiment).

Chromatography: Principles and applications of Paper chromatography , Thin layer chromatography, Gel filtration chromatography, Ion exchange chromatography, Affinity chromatography

Electrophoresis: Principle and applications of native polyacrylamide gel electrophoresis, SDS- polyacrylamide gel electrophoresis, 2D gel electrophoresis, Isoelectric focusing, Agarose gel electrophoresis, Southern and Western Blots.

Spectrophotometry: Scattering and absorption, transmittance, absorbance (optical density), Lambert-beer law. Instrumentation of UV-Vis absorption spectrophotometer, analysis of biomolecules using UV-Vis spectroscopy, colorimetry and turbidimetry**.** Introduction to emission spectroscopy: Fluorescence and phosphorescence and their applications in biology.

Unit 3 : Radioisotope techniques (5 hours)

Basic concepts on radioisotopes, commonly used radioisotopes (tritium, carbon 14, chlorine 36, lead 210, cobalt 60, iodine 131), nature of radioactivity, basic concept on detection and measurement of radioactivity, safety aspects.

MLBG-MD-CC-7-Pr

Biophysical Processes and Techniques (Practical) (1 credit /25 marks)

1. Measurement of relative viscosity/fluidity of DNA by Ostwald viscometer.

2. Separation of amino acids by paper / thin layer chromatography.

3. Light microscope observation of relative distribution of WBC in a fresh blood smear.

4. Measurement of absorption spectrum of chlorophyll by spectrophotometer/colorimeter.

Suggested Reading

1. Hallet FR, Speight PA and Stinson RH (1978) Introductory Biophysics. Chapman and

Hall Ltd.

2. Hallet FR, Stinson RH and Speight PA (1982) Physics for the biological sciences.

Methuen.

3. Srivastava, PK (2011) Elementary Biophysics. Narosa Publishing House

4. van Holde KE, Johnson WC and Ho PS (2005) Principles of Physical Biochemistry.

Pearson Education India

MLBG-MD-CC-8

Cell to Cell Communication and Immunology (3+1 credits)

Learning objectives

After attending this course, the student should be able to

1. understand how cells communicate with one another,
2. tell about basic cell signaling paths,
3. describe endocrine, paracrine, autocrine, and juxtacrine signaling,
4. understand the first line of defense against pathogens, including physical barriers, phagocytosis, complement activation, and inflammation,
5. understand antigen-specific immune response, including humoral immunity (antibody production) and cell-mediated immunity (T cell-mediated responses),
6. describe how cell communication and immune responses are involved in various diseases, including cancer, autoimmune disorders, and infectious diseases,
7. comprehend principles behind vaccine design and development.

MLBG-MD-CC-8-Th

Cell to Cell Communication and Immunology (Theory) (3 credits/ 75 marks)

Unit I – Cell to cell communication (25 hours)

Electrical communication and chemical communication.

Modes of cell signalling: Autocrine, paracrine, and endocrine signalling. Extracellular signalling molecules. Introduction of receptors and their roles in signal detection.

Basic cell signalling pathway: Reception-Transduction-Response.

Different types of receptors: Nuclear receptors for steroid hormone signalling (Ex: Estrogen signalling), receptor protein tyrosine kinases (RPTKs) (Ex: Activation of PLC and Ca^{2+} signalling), G-protein coupled receptors (GPCRs) (Ex: The cAMP signalling pathway: Second messengers and protein phosphorylation), non-enzyme containing receptors (Ex:

Cytokine signalling and JAK-STAT signalling pathway, Toll-like receptor signalling in innate and adaptive immunity).

Role of gap junctions in cell-cell communication.

Unit II - Immunology (20 hours)

Immune response – An overview. General features of innate and adaptive immunity.

Cells and molecules involved in innate and adaptive immunity (Stem cell, T-cell, B-Cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell and Dendritic cell).

Antigens, antigenicity and immunogenicity, Epitope, Immunoglobulin or antibodies (basic ideas), monoclonal and polyclonal antibodies, MHC molecules.

Humoral and cell-mediated immunity. Primary and secondary immune response

Immunological techniques (agglutination, precipitation, ELISA, RIA, immunofluorescence, flow cytometry, Western blot).

Active and Passive immunization. Vaccination, hypersensitivity and autoimmunity (basic concept).

MLBG-MD-CC-8-Pr

Cell to Cell Communication and Immunology (Practical) (1 credit/ 25 Marks)

1. Detection of blood group.

2. Immunodiffusion: Ouchterlony double diffusion technique.

Suggested reading

1. Alberts, B. et al. (2014) Molecular Biology of the Cell. 6th edition. W. W. Norton & Co.

2. Cooper, G. M. and Hausman, R. E. (2015) The Cell: A Molecular Approach. 7th edition. Sinauer Associates.
3. Berridge, M.J. (2014) Cell Signalling Biology. Portland Press.
4. Bradshaw, R. A. and Dennis, E. A. (2003) Handbook of Cell Signaling. Vol. I, II and III. Academic Press.
5. Hancock JT (2005) Cell Signaling. Oxford University Press.
6. Kindt TJ, Osborne BA and Goldsby RA. (2006) Kuby Immunology, 6th Edition. W. H. Freeman & Company.
7. Lydyard PM, Whelan A and Fanger MW (2000) Instant Notes in Immunology, BIOS Scientific publishers.

INTERDISCIPLINARY COURSE

MLBG-MD-ID-1-Th

Biostatistics without fear (3 credits/75 marks)

Learning objectives

After attending this course, the student should be able to

1. properly organize experimental data and describe its salient features.
2. explain what is a normal distribution
3. understand how to estimate population parameters from samples
4. explain and apply the concepts of statistical significance and p-value
5. do correlation and regression analysis.

Unit 1. Simple data analysis (17 hrs)

Making sense of your data: What is statistics? Descriptive and inferential statistics. How to collect a sample?

Describing your sample: Statistical variables. Error, accuracy, and approximations.

Summarizing your Data: Tables and diagrams. Central tendencies. Dispersion.

How does your data look? Distributions. The shape of a distribution. Skewed distributions. The normal distribution.

Unit 2. Estimates and inferences from your data (17 hrs)

How to go from samples to the population? The logic behind sampling. Sample-means and population-mean. Estimation of other parameters.

How to compare samples? From the same or different populations? Tests of significance. Significance of significance.

Unit 3. Relationships in your data (11 hrs)

Paired values. Kinds of correlation. The strength of a correlation. Correlation coefficients. Interpreting correlation coefficients. Predicting based on your data. Regression analysis.

Suggested reading

1. Pezzullo JC (2013) Biostatistics for dummies. John Wiley & Sons.

2. Rowntree D (2004) Statistics without tears. Pearson.

SKILL ENHANCEMENT COURSE

MLBG-MD-SEC-1

Basics of Molecular Diagnostics (3+1 credits)

Learning objectives

After attending this course, the student should be able to

1. understand the best practices to be followed in a laboratory setting
2. explain the mechanisms of some of the major infectious and non-infectious diseases
3. explain the principles of a number of important and widely-used laboratory diagnostic tests
4. have hands on experience of how to carry out simple laboratory diagnostic tests

MLBG-MD-SEC-1-Th

Basics of Molecular Diagnostics (Theory) (3 credits/75 marks)

Unit 1. Laboratory practices (5 hrs)

Biosafety practices, laboratory area flow, and practices to minimize contamination.

Unit 2. Mechanisms of infectious and non-infectious diseases (20 hrs)

Idea about the features of pathogenic and non-pathogenic microorganisms.
Mechanisms of pathogenicity: entry, colonization, course of infectious disease, duration of symptoms

Ideas about major non-communicable diseases (NCDs) — cardiovascular diseases, diabetes, cancer.

What is diabetes? What are the different types of diabetes? How to test for diabetes?

What are the risk factors for cardiovascular diseases? How to diagnose hypertension?

What is cancer? What are the major risk factors? Screening strategies for cancer.

Unit 3. Diagnostic methods (20 hrs)

Nucleic acid-based methods: Extraction methods, basic extraction steps, and nucleic acid analysis. Principles of PCR based diagnostic methods.

Protein-based methods: General properties and importance of clinically important enzymes like SGOT, SGPT, alkaline phosphatase and creatine kinase, lactate dehydrogenase. Principles involved in their tests.

MLBG-MD-SEC-1-Pr

Basics of Molecular Diagnostics (Practical) (1 credit/25 marks)

1. Isolation of pure culture by streak plate technique.

2. Antibiotic sensitivity assay by paper disc method.

3. Preparation of blood smear and Differential Leucocyte Count (D.L.C) using Leishman's stain,

4. Count platelets from peripheral blood smears.

Suggested reading

1. Iles RK and Docherty SM (Ed.s) (2012) Biomedical Sciences. Essential Laboratory Medicine. Wiley-Blackwell
2. Wilson K and Walker J (Ed.s) (2010) Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press