DRAFT SYLLABUS FOR
MINOR COURSE
OR
B. Sc. (MULTIDISCIPLINARY) PROGRAMIN

MOLECULAR BIOLOGY AND BIOTECHNOLOGY

Under National Education Policy-2020
(With effect from the session 2023-2024)

B. Sc. in Molecular Biology and Biotechnology

Based on NEP,2020

Minor Course (3 + 2 = 5 credits each)

(Opted by Students of Four-Year B. Sc. Honours/Honours with Research/ 3-Year Multidisciplinary UG Programme)

Semester	Course Code	Paper Title	Credits	Hours
I	MA-1T	Biomolecules (Theory)	3	45
	MA-1P	Biomolecules (Practical)	2	60
II	MA-2T	Cell Biology and Genetics (Theory)	3	45
	MA-2P	Cell Biology and Genetics(Practical)	2	60
III	MA-3T	Enzymes and Metabolism(Theory)	3	45
	MA-3P	Enzymes and Metabolism(Practical)	2	60
IV	MA-4T	Principles Of Molecular Biology(Theory)	3	45
	MA-4P	Principles Of Molecular Biology (Practical)	2	60
V	MA-5T	Bio-Analytical Tools and Immunology(Theory)	3	45
	MA-5P	Bio-Analytical Tools and Immunology(Practical)	2	60
VI	MA-6T	Recombinant DNA Technology and Microbial Biotechnology (Theory)	3	45
	MA-6P	Recombinant DNA Technology and Microbial Biotechnology (Practical)	2	60

Skill Enhancement Course: 3 credits each

SE-1: Fundamentals of Biostatistics and Bioinformatics
SE-2: Biotechnology in Sustainable Development

DETAILED SYLLABUS

Minor Course (3 + 2 = 5 credits each)

Semester I

MA-1T: BIOMOLECULES

THEORY (3 credits) TOTAL HOURS: 45

Unit 1: pH and Buffer (5 hrs): Ionization of water, Lowry Bronsted theory of acids and bases, pH and buffers, Henderson Hasselbalch Equation, Biological buffers, Importance ofbuffersin living system.

Unit 2:

Biomolecules (40 hrs):

Carbohydrates (12 hrs): Open chain and ring structures (Haworth projection formula) of Monosaccharides: Hexoses and Pentoses (Ribose and 2- deoxyribose), D- and L-configuration,Mutarotation, Anomers, and Epimers.Oxidation of sugars.Reducing and Non-reducing sugars, Disaccharides (sucrose, lactose, maltose), Structure of homopolysaccharides (glycogen, starch and cellulose).

Lipids (12 hrs): Classification of lipids, Nomenclature and structure of Saturated and Unsaturated Fatty acids, delta and omega-system; Essential fatty acids. Saponification number, Iodine number, Acetyl number of fats. Structure and Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol). Examples of Lipids as signalling molecules, cofactors and pigments.

Amino acids and Proteins (16 hrs):

General structure and classification of Amino Acids, Essential and non-essential amino acids, Zwitterionic structure, Acid-Base properties, Titration of amino acids, pK values and Isoelectric point,Formol titration of glycine. Reactions of carboxyl and amino groups, formation ofPeptide bond, Determination of N-terminal amino acid (Edman's method) and C–terminal amino acid (hydrazinolysis). Structural organization of proteins (primary, secondary, tertiary & quaternary), Covalent and Non-covalent interactions that stabilize the three-dimensional structures of proteins. Fibrous and globular proteins, Native structure of Proteins, Denaturation.

MA-1P: BIOMOLECULES

PRACTICAL (2 credits) TOTAL HOURS: 60

1. Preparation of phosphate buffer and measurement of pH.
2. Qualitative tests for reducing and non-reducing sugars, polysaccharide, lipid, amino acids and proteins.
3. Identification of unknown compounds (from sugars, polysaccharides, lipids, amino acids and proteins).
4. Formol titration of Glycine.

SUGGESTED READING

1. DasD. (1978) Biochemistry. Academic Publishers.
2. Conn EE and Stumpf PK. (1972) Outline of Biochemistry. John Wiley Publishers.
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. Berg JM, Tymoczko JL and Stryer L. (2011) Biochemistry, W.H.Freeman and Company.

Semester II

MA-2T: CELL BIOLOGY AND GENETICS

THEORY (3 credits) TOTAL HOURS: 45

Unit 1:Cell Biology (15 hrs): Cells as basic functional unit of life,classification of organisms by cell structure.

Structure of prokaryotic cell, Gram staining, bacterial cell wall (gram positive & gram negative), prokaryotic cell membranes, cytoplasm, ribosomes, nucleoid.

Structure, chemical composition and functions of eukaryotic cell membrane, Fluid Mosaic model of plasma membrane, Passive and active transport, Endocytosis andExocytosis.

Structure and functions of different cell organelles: Cytoskeleton, Nucleus, Endoplasmic reticulum, Golgi apparatus, Mitochondria, Chloroplast, Lysosome and Peroxisome.

Unit 2: Microscopy (5 hours): Optical microscopy: the nature of light—its particle and wave character. Ray diagrams and image formation. Simple and compound microscopes, Applications of optical microscopes, Numerical Aperture (NA), Resolution, Contrast, magnification, limit of resolution, Basic principles of oil immersion microscope. Limitations of optical microscopes. Electron microscopy---Basic working principle of TEM and SEM.

Unit 3: Basic Microbiology (10 hours)

Introduction to microbiology; general concepts on microbes and their distinctive characters; Morphology of bacteria; Physical conditions required for growth (temperature, oxygen, and pH); Basic nutritional requirements for growth (carbon source, nitrogen source, other growth factors like vitamin source, or any special requirement); Bacterial reproduction by binary fission, fragmentation and budding; a brief outline about bacterial growth curve. Control of microorganisms: Fundamentals of control.Definition of physical agents (high and low temperature, radiation, filtration) and chemical agents (phenol and phenolic compounds, alcohol, Chemotherapeutic agents). Introduction to antibiotics.

Unit 4: Mendelian Genetics (5 hrs): Mendel's Principles of inheritance;Law ofSegregation, Law of Independent Assortment.

Unit 5: Microbial Genetics (10 hours): Genetic recombination in bacteria: Mechanism of bacterial transformation, conjugation (Discovery, F factor, *Hfr* and $F^{/}$strains) and transduction (Generalized transduction and Specialized transduction).

MA-2P: CELL BIOLOGY AND GENETICS

PRACTICAL (2 credits TOTAL HOURS: 60

1. Simple staining of bacteria.
2. Gram staining of bacteria.
3. Negative staining of bacteria using nigrosin.
4. Determination of relative sizes of nucleus and cytoplasm of squamous cells.
5. Measurement of refractive index of a biological solution with the help of travelling microscope.

SUGGESTED READING

1. Rastogi SC.(2012) Cell and Molecular Biology. New age international publication.
2. Sharma VK.(1991) Techniques of microscopy. Tata McGraw Hill publication.
3. Karp G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.
4. De Robertis, EDP and De Robertis EMF. (2006) Cell and Molecular Biology. 8th edition. Lipincott Williams and Wilkins, Philadelphia.
5. Cooper GMand Hausman, RE. (2009) The Cell: A Molecular Approach. 5th Edition. ASM Press & Sunderland, Washington, D.C.,Sinauer Associates, MA.
6. Reimer L and Kohl H. (1984) Transmission electron microscopy, Springer.

Semester III

MA-3T: ENZYMES AND METABOLISM

THEORY (3 credits) TOTAL HOURS: 45

Unit 1: Enzymes(20 hrs): Nomenclature and IUB classification, active site, cofactors, coenzymes and prosthetic groups, metallo-enzymes and metal-activated enzymes, activation energy and transition state, catalytic efficiency, activity, specific activity and turnover no. Principles of Enzyme kinetics: Michaelis-Menten Equation, Significance of Km and Vmax, Determination of Km and Vmax, Lineweaver Burk Equation, Double reciprocal Plot, Effect of temperature, pH and Inhibitors (Reversible Inhibition: competitive, un-competitive and non-competitive and Irreversible Inhibition), Allosteric Enzymes and Feedback Inhibition, Isozymes.

Unit 2: Bioenergetics and Metabolism (25hrs): Bioenergetics: Importance of Gibb's free energy in living System, High energy compounds, Energy currency of the cell, Electron Transport Chain (ETC), Idea of Redox Potential, Chemiosmotic Hypothesis and Oxidative Phosphorylation, Inhibitors and Uncouplers.

Carbohydrate metabolism: Catabolism and Anabolism, Glycolysis - fate of pyruvate under aerobic and anaerobic conditions, Fermentation (only lactate and ethanol), TCA cycle, Gluconeogenesis, Pentose phosphate pathway, Overview of Glycogenesis and Glycogenolysis.

Catabolism of fatty acids: Transport of fatty acids into Mitochondria, β-oxidation of saturated fatty acids (Reactions and Energetics), Ketogenesis.

Catabolism of amino acids: Amino acids- Essential, non-essential, glucogenic and ketogenic, Transamination and oxidative deamination, Urea cycle (Reactions, enzymes, location, connection with TCA cycle).

MA-3P: ENZYMES AND METABOLISM

PRACTICAL (2 credits TOTAL HOURS: 60

1. Study activity of any enzyme under optimum conditions.
2. Study the effect of pH on the activity of alkaline phosphatase or amylase enzyme. Determination of optimum pH.
3. Study the effect of temperature on the activity of alkaline phosphatase or amylase enzyme. Determination of optimum temperature.
4. Study of enzyme kinetics (alkaline phosphatase or amylase): Determination of Km and Vmax by Lineweaver Burk Plot. Calculation of specific activity.
5. Study the effect of any inhibitor on enzyme activity by Lineweaver Burk Plot.

SUGGESTEDREADING

1. Das D. (1978) Biochemistry. Academic Publishers.
2. Conn EE and Stumpf PK. (1972) Outline of Biochemistry. John Wiley Publishers.
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. Berg JM, Tymoczko JL and Stryer L. (2011) Biochemistry, W.H.Freeman and Company.

Semester IV

MA-4T: PRINCIPLES OF MOLECULAR BIOLOGY

THEORY (3 credits) TOTAL HOURS: 45

Unit 1: Structure and Organization of The Genetic Material (20 hrs):

Nucleic acids: Structure of Nucleotides, Nucleotides as source of energy, component of coenzymes, second messengers. DNA structure – Watson-Crick model. A, B & Z forms of DNA, DNA supercoiling – linking number, negative and positive supercoilng, topoisomerases, quardruplex DNA, denaturation and renaturation of DNA, melting temperature (Tm), UV absorption and hyperchromic effect. Nucleosome structure and Genome organization.Structureof major types of RNA.

DNA as a store of information: Genes are mutable units, one gene-one protein hypothesis, DNA is the almost universal genetic material (Griffith's experiment, Avery, MacLeod and McCarty's experiment, Hershey-Chase experiment), Central Dogma of Molecular Biology.

Unit2: Mutation and Mutagenic agents (5 hrs): Definition of mutation, Gain of function and Loss of function mutation, Forward and Reverse mutation, Point mutation (Transitions, transversions, Missense mutation, Nonsense mutation, silent mutation, Frame shift mutation), Spontaneous mutation and Induced mutation, Mutagen – physical (Ionizingradiation, UV radiation), chemical (Base analogs, Nitrous acid, Acridine dyes, Alkylating agents), Ames test.

Unit 3: Replication of DNA (5 hrs): Semiconservative nature of DNA replication (Messelson and Stahl's experiment), Mechanism of bidirectional DNA replication in prokaryotes, Bacterial DNA Polymerases, Pre-primingproteins, Primosome and Replisome.

Unit4: Gene Expression and Regulation (15 hrs):

Transcription: Transcription in prokaryotes with *E. coli* as model system: RNA polymerase, promoter, initiation, elongation and termination of transcription, rho dependent and independent termination.Inhibitors of transcriptionActinomycin D and α- Amanitin.

Genetic code: Features of Genetic code,Wobble hypothesis.

Translation in prokaryotes: Role of m-RNA, t-RNA and r-RNA in protein synthesis, ribosome structure and assembly, Charging of t-RNA, aminoacyl t-RNAsynthetases, initiation, elongation and termination of protein synthesis in bacteria, Action of antibiotics that act as protein synthesis inhibitors - Streptomycin, Tetracyclin, Kanamycin, Chloramphenicol and Puromycin.

Regulation of transcription: Operon model of gene regulation, negative and positive regulation in prokaryotes, *lac* operon.

MA-4P: PRINCIPLES OF MOLECULAR BIOLOGY

PRACTICAL (2 credits) TOTAL HOURS: 60

1. Quantitative estimation of DNA by diphenylamine reactionusingcolorimeter.
2. Quantitative estimation of RNA by orcinol methodusingcolorimeter.
3. Study of absorption spectra of DNA and protein using UV-Visible spectrophotometer.
4. Extraction of chromosomal DNA from *E. coli* or from plant tissue.
5. Determination of Purity of DNA using UV-Visible spectrophotometer (A260/ A280measurement).

SUGGESTEDREADING

1. WatsonJD,BakerTA,BellSP,GannA,LevineMandLosickR.(2014)MolecularBiologyofthe Gene,6thedition,ColdSpringHarbourLabPress,PearsonPublication.
2. Alberts B and Jhonson AD.(2014)Molecular BiologyoftheCell,6th edition, Garland Science.
3. KrebsJ,GoldsteinE,KilpatrickS.(2013)Lewin'sEssentialGenes,3rdEd.,JonesandBartlettLearning.
4. GardnerEJ,SimmonsMJ,SnustadDP.(2008)PrinciplesofGenetics. 8thEd.Wiley-India.
5. Brown TA. (2007) Genomes-3. Garland Science Publishers.
6. Rastogi SC. (2012) Cell and Molecular Biology. New age international publication.

Semester V

MA-5T: BIO-ANALYTICAL TOOLSAND IMMUNOLOGY

THEORY (3 credits) TOTAL HOURS: 45

Unit 1: Centrifugation (5 hours): Theory of ultracentrifugation, Relative centrifugal force (RCF), Sedimentation rate sedimentation coefficient, Isopycnic (equilibrium) sedimentation (discussion with example e.g. Meselson andStahl Experiment).

Unit 2: Spectrophotometry (5 hours): Electromagnetic spectrum, Introduction to concepts of absorption and emission spectroscopy, Absorption of light, Transmittance, Absorbance (Optical density), Lambert-Beer's law and its limitations, Concept of Molar extinction co-efficient, Study of absorption spectra of Proteins and Nucleic Acids, Analysis of Proteins and Nucleic Acids using UV and Visible spectroscopy, Colorimetry.

Unit 3: Chromatography (10 hours): Partition co-efficient, paper chromatography and its applications (including 2-D), Thin layer chromatography. Column packing andfraction collection, Gel filtration chromatography, Ion- exchange chromatography and affinity chromatography, GLC, HPLC.

Unit 4: Electrophoresis (5 hours): Principle and applications of native polyacrylamide gel electrophoresis, SDS- polyacrylamide gel electrophoresis, 2D gel electrophoresis, Agarose gel electrophoresis.

Unit 5: Immunology (20hours): Immune response – An overview, Primary and secondary immune response, 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 antibody, MHC molecules, Humoral and cell-mediated immunity, Antigen-antibody reaction (basic ideas), Immunological techniques (agglutination, precipitation, ELISA, RIA, immunofluorescence, flow cytometry Western blot),Vaccination, hypersensitivity and autoimmunity (basic concept).

MA-5P: BIO-ANALYTICAL TOOLS AND IMMUNOLOGY

PRACTICAL (2 credits) TOTAL HOURS: 60

1. Separation of amino acids by paper chromatography.
2. Separation of sugars by paper chromatography.
3. Separation of proteins by SDS- PAGE.
4. Separation of lipids by TLC.
5. Detection ofblood group.
6. Immunodiffusion: Ouchterlony double diffusion technique.

SUGGESTED READING

1. Freifelder D. (1982) Physical Biochemistry: Applications to Biochemistry and Molecular Biology, W. H. Freeman.
2. Wilson K and Walker J. (2010).Principles and Techniques of Biochemistry and Molecular Biology. 7th Ed., Cambridge University Press.
3. Nelson DL and Cox MM. (2008) Lehninger Principles of Biochemistry, 5th Ed., W.H. Freeman and Company.
4. HallettFR, Speiglet PA and Stinson RH. (1982) Physics for the biological sciences. Chapman and Hall.
5. Kindt TJ, Osborne BA and Goldsby RA. (2006) Kuby Immunology, 6th Edition. W. H. Freeman & Company.
6. Lydyard PM, Whelan A and Fanger MW.(2000) Instant Notes in Immunology, BIOS Scientific publishers).

Semester VI

MA-6T: RECOMBINANT DNA TECHNOLOGY AND MICROBIAL BIOTECHNOLOGY

THEORY (3 credits) TOTAL HOURS: 45

Unit 1: Introduction to Molecular Cloning (30 hrs): Vectors: Characteristics of cloning vectors, Plasmids (pSC101, pBR322, pUC18/I9), Bacteriophage lambda insertion and replacement vectors, M13 based vectors, Cosmids, YACs and Ti plasmid. Shuttle vectors and Expression vectors: *E.coli lac* and T7 promoter-based vectors. Enzymes used in Molecular Cloning: Restriction enzymes. Types I, II and III, nomenclature, use of Type II restriction enzymes in cloning, Isoschizomers and Neoschizomers, Restriction Mapping, Restriction Fragment Length Polymorphism (RFLP). DNA ligases, Terminal deoxynucleotidyltransferase, Polynucleotide Kinase, Phosphatases and Reverse Transcriptase. Cloning strategies: Construction of recombinant DNA: Joining of cohesive ends and blunt ends, c-DNA synthesis and cloning. Transformation of *E.coli* host by Calcium chloride method and electroporation. Methods used in Molecular Cloning: Agarose gel electrophoresis of DNA, Southern, Northern and Western blotting.

Unit 2: PCR Techniques: (5 hrs) Principle of Polymerase Chain Reaction, RT-PCR, Real-Time PCR and their applications.

Unit 3: MicrobialBiotechnology: (10 hrs)

Applications in human therapeutics (insulin, hGH), agriculture (Bt-cotton, brinjal)and food technology (Flavour savour tomato). Recombinant microbial production processes in pharmaceutical industries - recombinant vaccines (Hepatitis B vaccine).

Immobilization methods and their application: Whole cell immobilization.

MA-6P: RECOMBINANT DNA TECHNOLOGY AND MICROBIAL BIOTECHNOLOGY

PRACTICAL (2 credits) **TOTAL HOURS: 60**

1. Studyyeast cell immobilization in calcium alginate gels.
2. Isolation of plasmid DNA.
3. Agarose Gel Electrophoresis of plasmid DNA.
4. Preparation of competent cells for transformation by calcium chloride method.
5. Transformation of *E.coli* host cell with plasmid DNA.
6. 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. RatledgeC and Kristiansen B. (2001) Basic Biotechnology. 2nd Edition. Cambridge University Press.
5. Gupta PK. (2009) Elements of Biotechnology. 2nd edition. Rastogi Publications.
6. Glazer AN and Nikaido H. (2007) Microbial Biotechnology. 2nd edition. Cambridge University Press.

Skill Enhancement Course: 3 credits each

SE-1: FUNDAMENTALS OF BIOSTATISTICS AND BIOINFORMATICS

THEORY (3 credits) TOTAL HOURS: 45

Unit 1: Introduction to Biostatistics (8 hrs):

Keywords and terms used in biostatistics. Concept of frequency distribution (frequency distribution table, simple and group frequency distribution, data presentation), mean, median, mode, standard deviation, Simple problems on mean, median, mode and standard deviation.

Unit 2: Statistical Distribution (12 hrs):

Normal, binomial, poisson's distribution.

Unit 3: Introduction to Bioinformatics (25hrs):

Idea of Computational Biology and it's need in biological study. Nucleic acid and protein sequence database and information retrieval; sequence file formats - FASTA & GENBANK. Sequence alignment – Concept on local and global alignment; pairwise and multiple sequence alignment. Pairwise alignment tool - BLAST and multiple sequence alignment tool - Crustal ω. Protein and nucleic acid structure database: The Protein Database (PDB); information retrieval from structural database. Visualisation of protein 3D structures using RASMOL/PyMol.

SE-2: BIOTECHNOLOGY IN SUSTAINABLE DEVELOPMENT

THEORY (3 credits) TOTAL HOURS: 45

Unit 1: Biofertilization, Phytosimulation, Bioinsecticides (15 hours):

Plant growth promoting bacteria, biofertilizers – symbiotic (*Bradyrhizobium, Rhizobium, Frankia*), Non-Symbiotic (*Azospirillum, Azotobacter*, Mycorrhizae, Phosphate solubilizers, algae), Novel combination of microbes as biofertilizers.

Unit 2: Secondary Agriculture Biotechnology (15 hours):

Biotech feed, Silage, Biomanure, biogas, biofuels – advantages and processing parameters.

Unit 3: GM crops (15 hours):

Advantages, social and environmental aspects, Bt crops, golden rice, transgenic animals.

SUGGESTED READING

1. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA

2. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press

3. Barton LL & Northup DE (2011). Microbial Ecology. 1st edition, Wiley Blackwell, USA

4. Altman A (1998). Agriculture Biotechnology, Ist edition, Marcel decker Inc.

5. Mahendra K. Rai (2005). Hand Book of Microbial Biofertilizers, The Haworth Press, Inc. New York.

6. Reddy, S.M. et. al. (2002). Bioinoculants for Sustainable Agriculture and Forestry, Scientific Publishers.