SIES College of Arts, Science & Commerce
RISE WITH EDUCATION

SIES College of Arts, Science and Commerce
(Autonomous)
Sion (West), Mumbai – 400022.

Faculty: Science

Program: M.Sc.

Subject: BIOCHEMISTRY

Academic Year: 2023 – 2024

(NEP-2020 implementation)

M.Sc.

Semester I and II

Credit Based Semester and Grading Syllabi approved by Board of Studies in Biochemistry

with effect from 2023-2024

Content

PREAMBLE

The two years Masters programme in Biochemistry endeavours to provide the student with excellent training in Biochemistry. The course emphasizes on strengthening the fundamental concepts in the subject. At the same time, the programme aims to provide the student an exposure to the recent and emerging advancements in the field.

In addition to the theoretical knowledge, emphasis is also given to sharpen the practical skills of the student for gainful employment. Soft skills development component aims to provide the students with essential skills required for effective communication, and to apprise them of business communication and its role in corporate environment.

The programme also aims to impart competence in applying statistics to biological research and make the learner familiarized with the fast emerging field of Bioinformatics and applications of computers in Biochemistry.

Furthermore, the programme includes dissertation to be carried by every student during the second year under the supervision of a research guide or mentor. This not only provides the student an opportunity for hands-on training in research but grooms the learner in various aspects of research like the habit of scientific reading, research methodology, analytical ability, independent thinking and scientific writing.

In a nut shell the course aims to train the student for a career in industry/ research center and impart competence to qualify competitive exams in the subject.

CREDIT STRUCTURE FOR MSc PART I

Semester	Core 1	Core 2	Core 3	DSE	RM	OJT/ FP	Credit/ Semester	Degree/ Cumulative credit
I	6C	6C	2C	4C	4C	Nil	22 C	PG Diploma Certificate 44C
II	6C	6C	2C	4C	Nil	4C	22 C	
Total (I+II)	12C	12C	4C	8C	4C	4C	44 C	

DSE: Discipline Specific Elective

RM: Research Methodology

OJT: On Job Training

FP: Field Project

Summary of courses offered by the Department

Sr. no	Course	Title	Credits		
			Theory	**Practical**	**Total Credits**
Semester I					
1	Core 1	Biomolecules	4C	2C	6C
2	Core 2	Cell Biology	4C	2C	6C
3	Core 3	Applied Microbiology	2C		2C
4	DSE	Genetics	3C	1C	4C
5	RM	Research Methodology	3C	1C	4C
Total			**16 credits**	**6 credits**	**22C**
Semester II					
1	Core 1	Metabolism & Metabolic Disorder	4C	2C	6C
2	Core 2	Medical Biochemistry	4C	2C	6C
3	Core 3	Biopharmaceuticals	2C		2C
4	DSE	Applied Biochemistry	3C	1C	4C
5	OJT/ Field Project	OJT/ Field Project (Mandatory in case of exit after one year)		4C	4C
Total			**13 credits**	**9 credits**	**22C**

Summary of Course-wise Units

SEMESTER I

Course Code	Unit	Topic Headings	Credits	L/Week
Core 1: Biomolecules	I	Carbohydrates, Lipids & Nucleic Acids	4	4
	II	Proteins & Proteomics		
	III	Enzymes		
	IV	Plant Biomolecules		
Core 1 Practical		Biomolecules-Practical	2	4
Core 2: Cell Biology	I	Cell Architecture	4	4
	II	Membrane Biochemistry		
	III	Cell Signalling		
	IV	Bioenergetics		
Core 2 Practical		Cell Biology-Practical	2	4
Core 3: Applied Microbiology	I	Industrial Microbiology	2	
	II	Medical Microbiology		
DSE: Genetics	I	Genetics	3	3
	II	Genetic Recombination		
	III	Extranuclear Inheritance; Population Genetics		
DSE Tutorial		Chromosomal Aberrations	1	
Research Methodology	I	Descriptive Statistics & Probability	3	3
	II	Estimation & Data Analysis		
	III	Clinical Interventional Studies		
Research Methodology Practical		Bioinformatics	1	1

MSc Theory Syllabus

Course **Core Paper 1** **Credits:4**
60 hours

BIOMOLECULES I **No of Lectures**

Course Outcome: *On completing the course, the learner should be able to*

1. *Elaborate on the structure and function of proteins, carbohydrates, lipids and nucleic acids. Be abreast with the recent developments and innovations in commercial applications of biomolecules*
2. *Discuss the various aspects of proteomics i.e the methods and techniques employed and appreciate its application health and disease*
3. *Apply the knowledge of enzyme and enzyme kinetics to industrial and clinical studies*
4. *Understand plant metabolism and its application.*

Unit 1 Carbohydrates, Lipids & Nucleic Acids **15**

1.1 Carbohydrates: Mucopolysaccharides; Glycosaminoglycans; Proteoglycans. Glycoproteins; Carbohydrate-binding proteins- lectins.

1.2 Carbohydrates of commercial importance: Starch, modified starch, cellulose, dextrins, cyclodextrins, maltodextrins, pectin, chitosan, microbial polysaccharides.

1.3 Lipids: Structural lipids: Chemistry, properties and functions of membrane lipids- Glycerophospholipids, plasmalogens, sphingolipids,

1.4 Chemistry and functions of Lipids as signals: phosphatidylinositol, eicosanoids, steroid hormones.
Lipids as cofactors: vitamin E, K and ubiquinone.
Composition and biological role of lipoproteins

1.5 Outline of separation and analysis of lipids.

1.6 Nucleic acids: Properties of DNA in solution; Tm of DNA, its relation to GC content, unique and repetitive sequences of DNA, Cot curve and its significance, C-value paradox.

1.7 Organization of eukaryotic DNA: Histones, nucleosomes, structure of chromatin; Eukaryotic chromosomes, lampbrush & polytene chromosomes; overlapping genes, Cryptic genes.

RNA: Structure, function and types of RNAs.

1.8 Genome of prokaryotes, viruses, mitochondria, chloroplasts.

(*Pre-requisite: Learner should be well versed with- structure and properties of monosaccharides, disaccharides, fatty acids, triacylglycerol, waxes, structure of nucleic acids, Watson & Crick's model of DNA, Chargaff's rule.)*

Unit 2 Proteins & Proteomics **15**

2.1 An overview of protein structure; Globular and fibrous proteins; Structural hierarchy of protein; Dihedral angles. Ramachandran plot; Location of disulfide bonds, peptide mapping motifs, and folds in protein structure. Secondary structure; Tertiary structure; Domains, Quaternary structure.

2.2 Structure-function relation of proteins- Hemoglobin
Protein-Protein interaction (actin, tubulin); Leucine zipper, Zinc finger.

2.3 Properties and mechanisms of protein folding. Prion proteins

2.4 Biologically important peptides: Adrenocorticotrophic Hormone-ACTH, Thyrotropin Releasing Hormone, Corticotrophin, Oxytocin, Vasopressin, Gastrin, Angiotensin, carnosine and anserine, bradykinin, encephalin.

2.5 Purification of proteins:
General strategy, Source identification, isolation, recovery, concentration. Partial/total purification by salting in, salting out, precipitation, ion exchange, dialysis, ultra-filtration, column chromatography.
(Gel filtration, Affinity, HPLC); determination of purity; gel electrophoresis

2.6 Proteomics
Overview, tools, and applications; Two-dimensional polyacrylamide gel electrophoresis; Protein spot detection.
Mass spectrometry: matrix assisted laser desorption.
ionization MS, electrospray ionization MS, and tandem MS for protein identification; Identification of protein-protein interactions; Protein complexes.
(Prerequisite: Learner should be well versed with - Structure of standard amino acids, properties of peptide bond, structural hierarchy of proteins)

Unit 3 Enzymes **15**

3.1 Mechanism of enzyme reaction: Acid –Base, electrostatic & covalent catalysis. Mechanism of chymotrypsin (serine protease) and hexokinase/ enolase.

3.2 Kinetics of enzyme catalyzed reactions; steady state hypothesis and derivation of Michaelis-Menten equation. Significance of Km and Vmax and their determination using different plots; Double reciprocal plot. Enzyme inhibition: competitive, noncompetitive, and uncompetitive inhibition; Enzyme kinetics in the presence of inhibitors; Determination of Ki.

3.3 Regulatory enzymes: Allosteric Enzymes- mechanism, kinetic properties, role in metabolic regulation.
Covalent modification: phosphorylation
Proteolytic cleavage- zymogen activation

3.4 Multifunctional enzymes and multienzyme complexes.
Isoenzymes; Ribozyme; Catalytic antibodies

3.5 Applications of enzyme: Clinical (Diagnostic tools and laboratory agents; therapeutic enzymes) and industrial.

(Prerequisites: Learner should be well versed with - Enzymes as biological catalysts: Enzyme classification, Principles of enzyme-catalysed reactions: influence of enzymes on reaction rate, reaction equilibria; activation energy, binding energy.)

Unit 4 Plant Biomolecules **15**

4.1 Primary metabolites: Photosynthesis: Light independent reactions: Calvin cycle,
Photorespiration, C4 plants, CAM plants. Glyoxylate cycle.

4.2 Plant growth regulators- Auxins, Gibberellins, Cytokines Abscisic Acid, Ethylene, oligosaccharins, jassmonic acid, barssinosteroids

4.3 Secondary metabolites: Terpenes, phenolic compounds, nitrogen containing compounds

4.4 Plant defense against insect herbivores and pathogens

4.5 Plant pigments: Chlorophyll, carotenoids, anthocyanins, and betalains

(Prerequisite: Learner should be well versed with - Structure of plant cell and its organelles, Plant pigments, transport of molecules via xylem and phloem)

MSc Practical Syllabus

Syllabus of Practical of Semester I Core course 1

Course Outcome: *On completing the course, the learner should be able to*

1. *Solve numerical problems based on concept of molarity, normality, percent solutions*
2. *Employ volumetric and spectroscopic techniques for qualitative and quantitative estimation of biomolecules*
3. *Understand isolation, extraction, and purification techniques of enzymes from natural sources.*
4. *Employ enzyme kinetic studies to the appreciate the properties of enzyme*

Practical	**Biomolecules**	**2C**
1.	Estimation of protein by Folin Lowry and Bradford method	
2.	Estimation of proteins at 280 nm	
3.	Estimation of glucose by DNSA /GOD-POD	
4.	Estimation of vitamin C by DCPIP/ Folin Phenol	
5.	Estimation of free fatty acids.	
6.	Extraction and partial purification of amylase / transaminases/ alkaline phosphatases / /Proteases (precipitation by salts/solvent)	
7.	Determination of optimum pH, optimum temperature of amylase (or any other enzyme) from sweet potatoes/ moong (from any other source)	
8.	Determination of Km and specific activity of amylase/transaminase/alkaline phosphatase.	
9.	To study the effect of inhibitors on beta amylase.	

MSc Theory Syllabus

Course	Core Paper 2: Cell Biology	Credit: 4 60 hours
	Learning Outcome: *On completing the course, the learner should be able to* *1. Discuss the organization, biochemistry, and functions of the cell.* *2. Describe the structure and function of biological membranes and explain mechanisms of solute transport.* *3. Describe the processes of signalling.* *4. Recall the basic concepts of thermodynamics and extend their application to energy production pathways in animals and plants*	**No of Lectures**
Unit I	**Cell architecture** 1.1 Components and functions of cytoskeleton 1.2 Cell-cell interaction: Cell adhesion molecules (cadherins, integrins, selectins, and immunoglobulin-like adhesion molecules), cell junctions and types (occluding junctions, anchoring junctions), plasmodesmata, desmosomes 1.3 ECM: Structure, types, and functions of collagen, elastin, fibronectin, laminin. Basal lamina 1.4 Cell cycle and regulation (*Pre-requisite: Learner should be well versed with - structure of plant and animal cell and subcellular organelles)*	**15L**
Unit II	**Membrane Biochemistry** 2.1 Biological membrane: Functions, Composition, assembly, and properties: self- assembly, fluidity, asymmetry. 2.2 Specialized features like lipid rafts. 2.3 Erythrocyte membrane- composition and function Artificial Membranes- Liposomes, Preparation and applications. Concept of Supra-molecular assembly –Biological membranes, viruses, and Ribosomes. 2.4 Transport across membranes: Diffusion, Facilitated and active transport. Membrane transport proteins: Channels, pumps and carriers/transporters (uniport, symport, antiport) Mechanism and role of GLUT uniporter, Na + -Glucose symporter, Na^{+}-Ca^{2+} antiporter, Na^{+}-K^{+} ATPase and Ca^{2+}ATPase. Voltage and ligand gated channels	**15L**

2.5 Specialised mechanisms of transport –nuclear pores. endocytosis and exocytosis
(*Prerequisite: Learner should be well versed with-composition and structure of membrane lipids)*

Unit 3 **Cell signalling** **15L**

3.1 General principles of signaling by cell surface receptors, endocrine, paracrine and autocrine signaling, components of intracellular signal-transduction pathways, types of cellular responses induced by signaling molecules.
Extracellular messengers- amino acids and their derivatives, peptides and proteins, gases, steroids, and eicosanoids.
Receptors: GPCRs, RTKs, ligand-gated channels, intracellular receptors, and others.
3.2 Second messengers: cAMP, cGMP, IP3, diacylglycerol and Ca –their role and associated proteins G- protein coupled receptor system: Mechanism of activation of effector molecules; Action of glucagon and epinephrine.
Examples of physiologic processes mediated by GPCRs that activate phospholipase C, and GPCRs that regulate ion channels.
3.3 Signaling of insulin/EGF via activation of RTKs.
Cytokine/growth hormone signaling via JAK/STAT pathway. Ras proteins- MAPK pathway
Diseases related to defects in signaling pathways.

Unit 4 **Bioenergetics** **15L**

4.1 Basic concepts: laws of thermodynamics as applied to biological systems, enthalpy, entropy, free energy, standard free energy.
4.2 Role of high energy phosphates in bioenergetics.

4.3 Energy generation in animals: Structure of mitochondria, Electron Transport Chain-
Complexes and electron carriers, structure of F_0F_1 ATPase mechanism of oxidative phosphorylation. Uncouplers and Inhibitors of energy transfer.

MSc Practical Syllabus

Syllabus of Practical of Semester I Core course 2

Course Outcomes: On completing the course, the learner should be able to

1. *Co-relate the structure or chemistry of biomolecules to their properties an apply this knowledge in isolation of biomolecules for their industrial application.*
2. *Employ technique of chromatography in separation and purification of biomolecules*
3. *Study the structure of organelles using various visualization techniques.*
4. *Understand the use of animal models in designing an experiment.*

Practical	SIPSBCHP12- Cell Biology	2C
1.	Starch from potato and purity determination by Willstatter's method.	
2.	Modification of starch	
3.	Casein from milk	
4.	Chlorophyll from spinach	
5.	Betalains from beet root	
6.	Determination of membrane lipid composition of goat/sheep RBCs	
7.	Preparation of a temporary mount of a leaf peel to show stomata.	
8.	Staining and visualization of mitochondria by Janus green stain.	
9.	RNA staining by Methyl green pyronin.	
10.	Study of animal models (Zebra fish, Drosophila and Chick embryo)	
11.	Preparation of wine from banana peels.	

	Core Paper 3: Applied Microbiology **Course Outcome:** *On completing the course, the learner should be able to* *1. Understand the parameters that influence a bioprocess/ fermentation technology* *2. Discuss the production of industrially relevant compounds from microbial sources* *3. Describe the upstream and downstream processes in metabolite production* *4. Apply the knowledge of microorganisms in understanding the cause and effect of diseases.*	**2C** **Total Hours:30**
Unit 1	**Microbes of commercial importance** 1.1 Primary and secondary screening of microbes, inoculum preparation, fermentation media, industrial sterilization, strain improvement, Fermentation-submerged and solid-state fermentation, pure and mix culture fermentations 1.2 Bioreactor/fermenter; types of bioreactors Parameters for Bio process – Bio mass, Substrates, product, $O_2$and CO_2, Temperature, agitation. 1.3 Downstream processing, process for product recovery and by-product recovery 1.4 ABE fermentation, Lactic acid fermentation (Homo& Hetero) Ethanol fermentation, Butanol 1.5 Products from microorganisms – enzymes (Amylases, Pectinases and Proteases)	**18 h**
Unit 2	**Medical Microbiology** 2.1Bacterial and viral infections Staphylococcus and Streptococcus, Corynebacterium, Bacillus, Clostridium, Salmonella and Shigella, Mycobacterium 2.2 Viruses: General properties, Host-virus interaction Pox, Herpes, Picorna, orthomyxo and paramyxo viruses	**12 h**

MSc Theory Syllabus (DSE)

DSE : Genetics **Credit : 4**

On completing the course, the learner should be able to

1. *To understand the inheritance processes as extension of mendelian genetics*
2. *To apply Mendelian genetics in understanding patterns of inheritance*
3. *To familiarize the learner with recombination mechanisms in prokaryotes and eukaryotes.*
4. *To understand genetic changes within and between populations.*

Total hours: 45

Unit 1 **Genetics** **15L**

1.1 Extensions of Mendelian Genetics: Chromosomal theory of heredity, sex-linked inheritance, multiple alleles (ABO blood group, Drosophila eye color), extrachromosomal inheritance.
1.2 Mendelian genetics in humans: pedigree analysis
1.3 Modifications of dominance relationships, Gene interaction, epistasis, essential genes and lethal genes.
1.4 Sex determination, analysis of sex-linked trait in humans.
1.5 Environment and gene expression.
1.6 Problems based on the above-mentioned topics.

(Prerequisite: Mendelian Genetics)

Unit 2 **Genetic Recombination** **15L**

2.1 Genetic recombination in bacteria: conjugation, transformation & transduction
2.2 Mapping of genes by conjugation, transformation & transduction
2.3 Holliday & Messelson-Radding models of recombination; proteins and enzymes involved in genetic recombination.
2.4 Gene linkage & crossing over, tetrad analysis.
2.5 Transposable elements.
(Prerequisite: Basic structure of DNA, prokaryotic DNA replication and transcription)

Unit 3 **Extranuclear inheritance and population genetics** **15L**

3.1 Organization of extranuclear genomes.
3.2 RNA editing
3.3 Rules of extranuclear inheritance, examples of extranuclear inheritance.
3.4 Maternal effect.
3.5 Genetic structure of population, genotypic frequencies, and phenotypic frequencies.
3.6 The Hardy- Weinberg law

3.7 Genetic variation in space and time.
3.8 Changes in genetic structures of population: Mutation, genetic drift, migration, natural selection, simultaneous effects of mutation and selection, non-random mating.

MSc DSE Tutorial Syllabus

DSE: Chromosomal Aberrations **1C**

On completing the course, the learner should be able to

1. *To provide detailed understanding of types of DNA damage and the mechanisms involved in repair.*
2. *To apply the knowledge of karyotyping in deducing various diseases & disorders.*

Tutorial: 15hours

1. Types of mutations; Physical, chemical and Biological agents causing mutation
2. Mutational hot spot, reverse mutations , Mutagenesis, Ames test
3. Site directed mutagenesis
4. Structural and numerical abnormalities
5. Euploidy and aneuploidy (Autosomal and Sex chromosomes)
6. Karyotyping
7. Monosomies (Turner syndrome) Disomies and trisomies (Down Syndrome) and their causes

MSc Theory Syllabus

RESEARCH METHODOLOGY

	Research Methodology: Biostatistics **Course Outcome**: *On completing the course, the learner should be able to* *1. Compare and contrast the various sampling techniques and realize their importance in research.* *2. Employ statistical methods for analysis and interpretation of biological data.* *3. Analyse and interpret the demographic & diagnostic data using statistical tools and tests.*	**3C** **Total hours: 45**
Unit I	**Descriptive Statistics & Probability:** 1.1 Data: Definition, Types and Sources of data, Presentation of data. 1.2 Different Sampling techniques: Significance of correct sampling techniques, types of samples; Representative sample, sample bias. 1.3 Probability: Definition. Probability Distribution: Concept of Normal distribution and normal curve, Asymmetric distribution, Bayesian analysis. 1.4 Simple correlation and linear regression. *[Prerequisite: Measurement & scales of measurement, measures of central tendency (mean, median, mode), measures of dispersion (standard deviation, variance, coefficient of variance), standard error]*	15 L
Unit II	**Estimation and data analysis**: **2.1 Parametric Tests:** 2.1.1 Univariate and multivariate analysis. Brief introduction to Parametric analysis. 2.1.2 Hypothesis testing and method of hypothesis testing, Types of error; Significance of difference in means: Standard error of mean, Z-test, t-test (paired and unpaired), Standard error of proportion, F-test, ANOVA. **2.2 Non-Parametric Tests**: 2.2.1 Importance of non-parametric tests. 2.2.2 Mann-Whitney test, Wilcoxon test, Kruskal-Wallis test. 2.2.3 Chi square test, Test of goodness of fit, contingency square, homogeneity of Chi square. Yate's correction. **2.2.3 Measures of association**: 2.3.1 Multiple correlation and regression. 2.3.2 Yule's coefficient of association, Spearman's Rank correlation coefficient.	15L
Unit III	**Clinical Interventional Studies** **3.1 Diagnostic tests:** 3.1.1 Importance of statistics in diagnostic tests. 3.1.2 Sensitivity, specificity, positive predictive value, negative predictive value, accuracy, probability and odds ratio, likelihood ratio (LR), LR of positive test, LR of negative test Receiver operating characteristics (ROC) curves. **3.2 Demography & vital statistics** 3.2.1 Collection of demographic data, vital statistics.	15L

3.2.2 Measures of vital statistics: Rate of mortality, fertility, reproduction, morbidity, comprehensive indicators, indices of health population growth rates and density of population

MSc Practical Syllabus Semester I

Research Methodology Practical- Bioinformatics **1C**

Learning outcomes: *On completing the course, the learner should be able to*

1. *Explore databases to retrieve biological information.*
2. *Understand the complexities of protein structures using protein structural analysis tools.*

Practical: Total hours: 15

1. Data retrieval from NCBI- Pubmed, Medline, Nucleotide, UniGene, OMIM
2. Data retrieval from EBI- SwissProt, PIR, ENA,Taxon
3. Data retrieval using InterPro, SCOP
4. Database Similarity Search using BLAST variants
5. Multiple Sequence Alignments-Clustal Omega, T-Coffee
6. Structural analysis of proteins

References for Semester I

Study of Biomolecules

1. Berg, J. M., Tymoczko, J. L., & Stryer, L. (2007). Biochemistry, W. H.
2. Carl, B., John, T., & Carl, I. (1999). Introduction to protein structure.
3. Eisenberg, D. (1985). Proteins. Structures and molecular properties, TE Creighton. WH Freeman and Company, New York (1984), 515, $36.95.
4. Nelson, D. L., Lehninger, A. L., & Cox, M. M. (2008). *Lehninger principles of biochemistry*. Macmillan.
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Cell Biology

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. Molecular Biology of the Cell (Garland, New York, 2002).
2. Cooper, G. M., & Ganem, D. (1997). The cell: a molecular approach. *Nature Medicine*, *3*(9), 1042-1042
3. Lodish, H., Berk, A., Darnell, J. E., Kaiser, C. A., Krieger, M., Scott, M. P., & Matsudaira, P. (2008). *Molecular cell biology*. Macmillan.
4. Gerald Karp (2010). Molecular and Cell Biology- Concepts and Experiments 6th edition, John Wiley &sons, inc.

Enzymes

1. Dixon, M., & Webb, E. C. (1979). Enzymes (3rd edn). *Longmans, London*, *11*
2. Eisenthal, R., & Danson, M. J. (Eds.). (2002). *Enzyme assays: a practical approach* (Vol. 257). Practical Approach (Paperback).
3. Leskovac, V. (2003). *Comprehensive enzyme kinetics*. Springer Science & Business Media.
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Plant Physiology

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2. Dey, P. M. (2012). *Methods in plant biochemistry* (Vol. 1). Academic Press.
3. Hopkins, W. G. (1999). *Introduction to plant physiology* (No. Ed. 2). John Wiley and Sons.
4. Lea, P. J., & Leegood, R. C. (1993). Plant biochemistry and molecular biology.
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6. Prajapati, N. D. (2003). *Handbook of medicinal plants*. Agrobios.
7. Verma, V. (1982). *A text book of Plant Physiology*. EMKAY publications.

Genetics and Molecular Biology

1. Clark, D. P., & Pazdernik, N. J. (2013). *Molecular biology*. Elsevier.
2. Peter Russell (2016), I Genetics: A Molecular Approach
3. Elliott, W. H., Elliott, D. C., & Jefferson, J. R. (2005). *Biochemistry and molecular biology*. Oxford: Oxford University Press
4. Lewin, B., & Genes, I. X. (2008). Jones and Bartlett Publishers. *Inc., Sudbury*.
5. Lin, E. C., & Lynch, A. S. (2012). *Regulation of gene expression in Escherichia coli*. Springer Science & Business Media.
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7. Nelson, D. L., Lehninger, A. L., & Cox, M. M. (2008). *Lehninger principles of biochemistry*. Macmillan

Biostatistics and Bioinformatics

1. Ahuja, R. (2001). *Research methods*. Rawat.
2. Attwood, T. K., & Parry-Smith, D. J. (1999). Introduction to Bioinformatics, Pearson Education.
3. Bowers, D. (2008). Doing it right first time—designing a study. *Medical Statistics from Scratch*, 71-90.
4. Gollery, M. (2005). Bioinformatics: Sequence and Genome Analysis, David W. Mount. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press, 2004, 692 pp., $75.00, paperback. ISBN 0-87969-712-1. *Clinical Chemistry*, *51*(11), 2219-2219.
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Summary of Course-wise Units

SEMESTER II

Course Code	Units	Topic Headings	Credits	L/Week
Core 1 Metabolism & Metabolic Disorders	I	Carbohydrate metabolism & related disorders	4	4
	II	Lipid metabolism & related disorders		
	III	Protein metabolism & related disorders		
	IV	Nucleoprotein metabolism related disorders & free radical mechanism.		
Core 1 Practical		Clinical Biochemistry Practical	2	2
Core 2 Medical Biochemistry	I	Water & Electrolyte balance	4	4
	II	Pathophysiology of Common Diseases & Disorders		
	III	Pathophysiology of Cancer & Ageing		
	IV	Endocrine Disorders		
Core 2 Practical		Medical Biochemistry Practical	2	2
Core 3 Biopharmaceuticals	I	Biopharmaceuticals	2	2
	II	Drug discovery and development		
DSE: Applied Biochemistry	I	Bioprocess Technology	3	3
	II	Plant Tissue Culture		
	III	Animal Tissue Culture		
	IV	Vaccines		
	V	IPR & Ethics in Science		
DSE Practicals		Industrial Microbiology & Applied Biochemistry Practical	1	1

Semester II

MSc Biochemistry (Theory)

	Core I : Metabolism & Metabolic Disorders	**Credit: 4** **Total hours: 60**
	Course Outcome: *On completing the course, the learner should be able to* *1. Appreciate the multitude of biological pathways for metabolism of carbohydrate, proteins, lipids and nucleic acid* *2. Understand the regulation of metabolic pathways and its implications in diseases* *3. Understand the mechanism of free radical formation and its contribution to disease.*	
Unit 1	**Carbohydrate metabolism & related disorders**	**15L**
	1.1 Introduction to metabolism. metabolic pathways, experimental approaches to study metabolism	
	1.2 Digestion & absorption of Carbohydrates	
	1.3 Regulation of blood glucose level: by liver; renal regulation; hormonal regulation. Diabetes mellitus and its diagnosis – GTC, HbA1C	
	1.4 Glycogen metabolism: Synthesis, breakdown, regulation, Glycogen storage disorder.	
	1.5 Cori cycle, Glucose-Alanine cycle, Regulation of gluconeogenesis, Rapoport-Luebering cycle & its significance. Shuttles- malate-aspartate shuttle & glycerol phosphate shuttle.	
	1.6 Galactose metabolism; and fructose metabolism and fructose intolerance, essential fructosuria; lactose metabolism and lactose intolerance, glyoxylate pathway.	
	1.7 Overview of glycosaminoglycan metabolism and mucopolysaccharidoses. *(Prerequisite: An overview, Glucose metabolism: Glycolysis and its regulation, TCA and its regulation, Gluconeogenesis)*	
Unit 2	**Lipid metabolism & related disorders**	**15L**
	2.1 Digestion & absorption of Lipids: an overview.	
	2.2 Fatty acid oxidation: Oxidation of unsaturated, odd chain fatty acids. Disorders related to fatty acid oxidation: Genetic deficiencies in carnitine transport and Acyl-CoA dehydrogenase, Refsum's disease, Zellweger syndrome.	
	2.3 Fatty acid biosynthesis, role of elongases & desaturases; regulation of fatty acid biosynthesis synthesis of triacylglcerol and its regulation.	
	2.4 Phospholipid metabolism: Synthesis of phosphatidic acid, lecithin. Breakdown of phospholipids; action of phospholipases.	
	2.5 Synthesis and degradation of sphingomyelins;	

	Disorders related to sphingomyelin metabolism: Niemann-Pick disease, Faber's disease.	
	2.6 Glycolipid metabolism and related disorders: Cerebroside metabolism, metabolic disorders- Gaucher's and Krabbe's disease. Ganglioside metabolism and Tay Sach's disease.	
	2.7 Cholesterol metabolism: Biosynthesis, control, transport, utilization; hypo and hypercholesterolemia; atherosclerosis, Cholelithiasis.	
	2.8 Lipoprotein Metabolism: Metabolism of chylomicrons, VLDL, LDL, HDL. Disorders of lipoprotein metabolism: Hypo and hyper lipoproteinemias, fatty liver. *(Prerequisite: Structure of fatty acids (saturated & unsaturated), Beta oxidation of even chain saturated fatty acids, fatty acid biosynthesis of palmitic acid, ketone bodies formation and degradation.)*	
Unit 3	**Protein metabolism & related disorders**	**15L**
	3.1 Digestion & absorption of protein	
	3.2 Metabolism of amino acids: deamination, transamination, decarboxylation, ammonia formation, transport and detoxification in brain and liver. Urea cycle-regulation and disorder	
	3.3 Biosynthesis and/or catabolism and disorders; Glycine; aromatic amino acids- phe and tyr, trp; Sulphur containing; cys and met; Branched chain amino acids- leu, ile, val, Alanine, Aspartic acid, Glutamic acid, Serine, Proline, Hydroxyproline.	
	3.4 Formation of specialized products from amino acids and their functions- glutathione, creatine, creatinine, biogenic amines (dopamine, norepinephrine, tyramine, serotonin, melatonin, GABA, Histamine) polyamines (Putrescine, Spermodine, Spermine) Amino Acids as neuro-transmitters. *(Prerequisite: Basic structures of amino acids)*	
Unit 4	**Nucleotide metabolism and related disorders, free radical metabolism**	**15L**
	4.1 Nucelotide metabolism and related disorders	
	4.1.1 Digestion & absorption of Nucleic acid: an overview	
	4.1.2 Nucleotide Metabolism: Biosynthesis & degradation of purines & their regulation. Biosynthesis and degradation of pyrimidine and its regulation. Inter-conversion of Nucleotides.	
	4.1.3 Disorders of Purine and Pyrimidine Metabolisms, Gout, Lesch-Nyhan Syndrome, Orotic aciduria, Immune Deficiency Diseases associated with Adenosine deaminase-	

	ADA and Purine Nucleoside Phophorylase– PNP deficiencies.	
	4.2 Free radical Metabolism Free radical metabolism: Generation of free radicals, damage produced by reactive oxygen species (ROS), free radical scavenger systems (enzymatic & nonenzymatic). *(Prerequisite: Basic structures of nitrogenous bases and ribose)*	

MSc Semester II
MSc Biochemistry

Syllabus of Practical of Semester II – Core Course 2

On completing the course, the learner should be able to

1. Understand the principles of various organ functions and co-relate it with metabolic disorders
2. Analyze the biological compositions of various body fluids and interpret the abnormalities with diseased states

Practical	**Clinical Biochemistry**	**2C**
1.	Gastric Function Tests: Gastric Juice- Total and Free Acidity	
2.	Pancreatic Function Tests: i. Glucose Tolerance Test (GTT) ii. Estimation of Serum Amylase Activity.	
3.	Urine Analysis- Normal and Abnormal constituents, Microscopic examination	
4.	CSF analysis: i. Protein (Folin Lowry/Bradford) ii. Glucose (GOD-POD) iii. Demonstration of lumbar puncture procedure for CSF tapping(Video)	
5.	Antioxidant status of serum – FRAP assay	
	Demonstration experiments	
a.	Estimation of HbA1C	
b.	Estimation of serum lipase (Turbidimetric/ quinonimine dye test)	

Semester II
MSc Biochemistry (Theory)

	Core 2 : Medical Biochemistry	**Credit: 4**

		Total hours : 60
	Course Outcomes: *On completing the course, the learner should be able to* 1. *Understand the mechanism and significance of water, and electrolyte balance and associated disorders.* 2. *Explain the process of hemostasis and pathways of hemoglobin metabolism.* 3. *Comprehend the pathophysiology of common diseases, cancer and ageing and the significance of organ function tests.* 4. *Identify the causes and implications of hormonal imbalances.*	
Unit 1	**Water and Electrolyte balance** 1.1 Importance of Water. Total Body Water (TBW) and its distribution, normal water balance. (Intake and output of water, osmolarity of extracellular fluid) 1.2 Electrolytes. Distribution of electrolytes in body fluids. Water and Electrolyte balance. Regulation of Sodium and Water balance. (Aldosterone. Renin-Angiotensin system, aquaporins) Disorders of fluid and electrolyte balance. Expansion and contraction of ECF (isotonic, hypotonic, hypertonic) 1.3 Acid Base balance: Role of Blood buffers, Kidney, lungs Acidosis & Alkalosis and Compensatory mechanisms 1.4 Blood Gas Analysis (pH, pO2, pCO2, Bicarbonate) and interpretation	**15L**
Unit 2	**Pathophysiology of common diseases and disorders** 2.1 Clotting disorders and hemoglobinopathies 2.2.1 Conditions that cause excessive bleeding, thromboembolic conditions. 2.2.2 Hemoglobinopathies: 1) haemolytic anemia 2) Hb with abnormal O_2 affinity-High affinity (Polycythemia)Low affinity (Cyanosis) 3) Hb with structural and synthetic Variation in globin chains: Sickle cell Anemia (Structural) Alpha and Beta Thalassemia (Synthetic) 2.2 Pathophysiology of common diseases 2.2.1 CVD: Hypertension, angina, congestive heart failure, athersoclerosis, 2.2.2 Gastric disorders: peptic ulcers, gastritis, vomiting. 2.2.3 Biliary tract: Cirrhosis of liver, jaundice, hepatitis 2.2.4 Kidney: acute and chronic renal failure 2.2.5 Intestinal disorders: ulcerative colitis and tropical sprue	**15L**

	(Prerequisite: Structure of haemoglobin, clotting factors, mechanism of urine formation)	
Unit 3	**Pathophysiology of cancer and ageing** 3.1 Pathophysiology of cancer 3.1.1 Types of cancer, cancer metastasis 3.1.2 Carcinogens 3.1.3 Proto-oncogenes, oncogenes, oncogenic viruses 3.1.4 Tumor suppressor genes 3.1.5 Tumor markers 3.2 Ageing 3.2.1 Signs, theories (Free Radical theory, Glycation Theory). 3.2.2 Molecular Mechanisms 3.2.3 Mitochondria and ageing, protein damage & maintenance, neurodegeneration, DNA damage & repair, telomers, telomerase 3.2.4 Cellular senescence and apoptosis 3.2.5 Longeivity genes, Sirtuins, Deacetylases, hormones, biomarkers of ageing; Interventions to delay ageing.	**15L**
Unit 4	**Endocrine disorders** 4.1 Hypopitutarism and Hyperpiturism 4.1 Diabetes mellitus and its types, Diabetes insipidus 4.2 Hypothroidism (Cretenism, Myexedemea, Goitre and its types) and hyperthyroidism (Grave's disease) 4.3 Hypoparathyroidism and Hyperthyroidism 4.4 Addisons disease, Cushing's disease, and Conn's syndrome, pheochromocytomas 4.5 Gigantism and dwarfism 4.6 Hypogonadism 4.7 Menstrual cycle, PCOD, PCOS, Amenorrhoea, Dysmenorrhea *Prerequisite : Hierarchical organization and functions of hormones*	**15L**

Semester II
MSc Biochemistry

Syllabus of Practical of Semester II

On completing the course, the learner should be able to

1. Understand the principles of various organ functions and co-relate it with metabolic disorders
2. Estimate various biomolecules and co-relate it with diseased states
3. Analyze the electrolyte composition and compare the various metabolic disorders

Practical	**Medical Biochemistry**	**2C**
1.	Liver Function Tests:	
	a. Estimation of serum ALT, AST, Total & direct bilirubin. alkaline phosphatase	
	b. Estimation of serum Total Proteins, Albumin & A/G ratio.	
2.	Renal Function Tests:	
	a. Urea and Urea Clearance Test	
	b. Creatinine and Creatinine Clearance Test	
3.	Lipid Profile:	
	a. Estimation of serum total cholesterol	
	b. Estimation of HDL	
	c. Estimation of Triglycerides	
	d. Estimation of LDL by calculation	
4.	Estimation of serum acid phosphatase	
5.	Estimation of serum electrolytes (Na+, K+, Cl-).	
	Demonstration experiments	
	Separation of LDH isoenzymes	
	Arterial Blood Gas Analysis	

Semester II
MSc Biochemistry

	Core 3: Biopharmaceuticals ***Course Outcome****: On completing the course, the learner should be able to*	**Credits: 2C**

	1. Recognize the role of natural compounds as biopharmaceuticals in drug discovery *2. To introduce the basic concepts of drug absorption, distribution, metabolism and excretion.* *3. To understand the chemistry of drugs with respect to their pharmacological activity, understand the drug metabolic pathways, adverse effects and therapeutic value of drugs* *4. To study natural products as drugs and provide an overview of the steps in drug discovery.*	**Total Hours:30**
Unit 1	**1.1 Biomolecules as pharmaceuticals**: Introduction to terms: Drug/Pharmaceutical, Biopharmaceutical, Biologic 1.2 Pharmaceuticals of plant origin: Aspirin (salicylate), Alkaloids: Atropine, morphine, cocaine, ephedrine, papaverine, quinine, vinblastine and vincristine. Xanthines: caffeine and theophylline Terpenes: Taxol; Glycosides: Digoxin and Digitoxin 1.3 Pharmaceuticals of animal origin: Hormones: Sex hormones- Androgens, Progesterone and oestrogen; Adrenaline, Glucocorticoids and prostaglandins 1.4 Pharmaceuticals of microbial origin: Antibiotics: Penicillins, Cephalosporins, Tetracyclines, Aminoglycosides (streptomycin), Ansamycins (Rifamycin) Peptide antibiotics: Bacitracin, Gramicidin and Vancomycin	
Unit 2	**Drug Discovery and Development:** 2.1 Introduction to Pharmacology, Pharmacognosy, Pharmacokinetics, pharmacodynamics 2.2 Drug Discovery: Target identification and validation, lead identification (random screening and rational design approach) and optimization. 2.3 Pre-clinical trials: Pharmacokinetic profile, Pharmacodynamics profile, Bioavailability, bioequivalence, toxicity study and Clinical trial –phases 2.4 Role of regulatory Authority- FDA; IND, NDA	

Semester II
MSc Biochemistry

	DSE : Applied Biochemistry	**Credits: 3C**

	***Course Outcome**: On completing the course, the learner should be able to* **1.** *Justify the role of plants and microbial cells in production of biologically and industrially important metabolites* *2. Appreciate the role of microbes in mineral leaching and bioremediation and management and treatment of waste water* *3. Understand the isolation, extraction, purification, and application of compounds from plant and animal origin* *4. Explain various techniques employed for culturing of plant and animal cells in-vitro* *5. Compare and contrast the various vaccines used in treatment of diseases*	**Total Hours 45**
Unit 1	**Industrial Biochemistry** 1.1 Primary metabolites (Glutamate, vit B12), Antibiotics (Penicillin), Beverages (wine) bacterial and fungal polysaccharides	**15L**
	1.2 Microbes in mineral recovery - Bioleaching and Biosorption, Bioremediation: Phytoremediation and microbial remediation. Production of Biomass, Production of Single cell protein, and microbial steroid bio transformations.	
	1.3 Biogas Production. Role of Methanogens and Acetogens	
	1.4 Manufacturing and refining of cane sugar; Extraction and refining of vegetable oils; Extraction of plant pigments (chlorophyll, carotene, lycopene, curcumin) and essential oils. 1.5 Isolation and applications of non – catalytic industrial proteins – casein, whey proteins, Egg proteins, wheat germ proteins	
Unit 2	**Plant Tissue Culture (PTC)** 2.1 Principles, techniques, methodology and applications of PTC 2.2 Micro-propagation and protoplast fusion 2.3 Suspension cultures for production of secondary metabolites 2.4 Use of PTC in production of transgenics.	**10 L**
Unit 3	**Animal Tissue Culture (ATC)** 3.1 Principles, techniques, methodology and applications of ATC 3.2 Culture methods: hanging drop, suspension and mono layer. Behavior and characteristics of cells in culture, primary and established cell lines.	**10 L**

	3.3 Frontiers of contraceptive research, cryopreservation of sex gametes & embryos, ethical issues in embryo research.	
Unit 4	**Vaccines** 4.1 Vaccines, types of vaccines & anti – toxoid technology for measles, poliomyelitis, typhoid, Hepatitis B, AIDS, anti-tetanus,influenza,BCG.	**10 L**

Semester II
MSc Biochemistry DSE – Applied Biochemistry

At the end of the course, the learner should be able to

1. *Acquire practical skills in microbiological techniques like enumeration, isolation and identification of microbes*

2. Develop practical skills in isolation and characterization of plant metabolites

	Applied Biochemistry	**1 C Total Hours**
1	Staining : Gram, Capsule, Spore, and Negative	
2	Preparation of media and Sterilization Methods	
3	Techniques for preservation of cultures: sub-culturing, glycerol stocks, lyophilization	
4	Enumeration of bacteria: opacity tube, optical density, Viable count	
5	Growth curve of *E. coli*/Yeast	
6	Isolation of bacteria from natural sources: air, water and food	
7	Study of pure cultures of *E. coli* and *S. aureus* on selective media	
8	Biochemical tests for identification of bacteria: IMViC, catalase, oxidase	
9	Antibiotic sensitivity by disc diffusion or well diffusion Method	
10	Curcumin from Turmeric	
11	Carotenes from carrots	
12	Lycopene from Tomato	
13	Caffeine from coffee beans	

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