



Mahajana Education Society (R)
Education to Excel
SBRR Mahajana First Grade College (Autonomous)
Post Graduate Wing
Pooja Bhagavat Memorial Mahajana Education Center
KRS Road, Metagalli, Mysuru

SCHOOL OF LIFE SCIENCES

M.Sc. BIOCHEMISTRY PROGRAM
Choice Based Credit System (CBCS)

**SYLLABUS WITH STRUCTURE FOR CREDIT DISTRIBUTION FOR
M.Sc., DEGREE IN BIOCHEMISTRY**

School of Life Sciences

Credit Distribution for Each Semester:

Semesters	Hard Core (HC)		Soft Core (SC)		Open Elective (OE)		Total	
	Number of Papers	Credits	Number of Papers	Credits	Number of Papers	Credits	Number of Papers	Credits
I semester	5	16	02	06	-	-	7	22
II semester	5	16	01	03	01	04	7	23
III semester	4	12	02	06	-	-	6	18
IV semester	1	10	01	03	-	-	2	13
Total	15	54	06	18	01	04	22	76

Credits to be claimed for Successful award of M.Sc. degree in Biochemistry

	Minimum Required	Obtained
Minimum Credits from Hard Core	42	54
Minimum Credits from Soft Core	16	18
Minimum Credits from Open Elective	04	04
Minimum Total Credits	76	76

I Semester

Sl. No.	Title of the Paper	Course Type	Credit Pattern			Total Credits
			L	T	P	
1	Fundamentals of Biochemistry	FCHC	3	1	0	4
2	Techniques in Biology	FCHC	3	1	0	4
3	Molecular Cell Biology	FCHC	3	1	0	4
4	Practical IA (Experiments in Fundamentals of Biochemistry & Techniques in biology, Laboratory Visit and Tour Report)	HC	0	0	4	2
5	Practical IB (Experiments in Molecular Cell Biology & Genetics; Seminar)	HC	0	0	4	2
	Soft Core (Any Two)					
6	Genetics	FCSC	3	1	0	3
7	Microbiology	FCSC	3	1	0	3
	Genetic Engineering	FCSC	3	1	0	3
TOTAL CREDITS						22
5 Hard Core (HC): 16 Credits; 2 Soft Core (SC): 06						

II Semester

Sl. No.	Course	Course Type	Credit Pattern			Total Credits
			L	T	P	
1	Molecular Biology	FCHC	3	1	0	4
2	Metabolism of Carbohydrates	HC	3	1	0	4
3	Bioorganic and Bioinorganic Chemistry	HC	3	1	0	4
4	Practical IIA (Experiments in Molecular Biology; Bioorganic & Bioinorganic chemistry; Laboratory visits and Tour report)	HC	0	0	4	2
5	Practical IIB (Experiments in Metabolism of Carbohydrates and lipids, Seminar)	HC	0	0	4	2
Soft Core (Any One)						
6	Metabolism of Lipids	SC	3	1	0	3
	Molecular Diagnostics	SC	3	1	0	3
Open Elective						
7	Fundamentals of Biochemistry and its applications (For students of other disciplines)	OE	3	1	0	4
TOTAL CREDITS						
5 Hard Core (HC): 16 Credits; 1 Soft Core (SC): 03; 1 Open elective (OE): 04						23

III Semester

Sl. No.	Course	Course Type	Credit Pattern			Total Credits
			L	T	P	
1	Immunology	FCHC	3	1	0	4
2	Enzymology	HC	3	1	0	4
3	Practical-III A Experiments in Immunology, Metabolism of Amino acids, Proteins, and Nucleic acids; Study tour and tour report.	HC	0	0	4	2
4	Practical IIB Experiments in Enzymology and Seminar	HC	0	0	4	2
Soft Core (Any Two)						
5	Metabolism of Nucleic Acids	SC	3	1	0	3
6	Metabolism of Amino Acids and Proteins	SC	3	1	0	3
	Membrane Biology	SC	3	1	0	3
TOTAL CREDITS						
4 Hard Core (HC): 12 Credits; 1 Soft Core (SC): 06						18

IV Semester

Sl. No.	Course	Course Type	Credit Pattern			Total Credits
			L	T	P	
1	Project Work	HC	0	2	20	10
Soft Core (Any One)						
2	Clinical Biochemistry	HC	3	1	0	3
3	Biostatistics, Bioinformatics and Research Methodology	HC	3	1	0	3
TOTAL CREDITS						
1 Hard Core (HC): 10 Credits; 1 Soft Core (SC): 03						13

LTP: Lecture, Tutorial, Practical

FCHC: Foundation Course Hard Core; FCSC: Foundation Course Soft Core.

M.Sc. Biochemistry I Semester	Fundamentals of Biochemistry	FCHC – Foundation Course Hard Core
Total Hours: 48	Credits: 04 (LTP - 3:1:0)	Total Marks: 15+15+70 = 100

Learning Objectives: Students should study this paper to know –

- The basics of biomolecules.
- Functions of biomolecules in the biological system.
- Interactions among the biomolecules in the nature.

Module	Course contents	
1	Basics of Chemical Bonding and Carbohydrates Bonding: Covalent bond; coordinate bond; coordinate bond formation in transition metals. Bonding of iron in hemoglobin and cytochromes, cobalt in Vit B ₁₂ , magnesium in chlorophyll. Special properties of water; Structure and bonding, non-covalent interactions, reactions of carbohydrates. Carbohydrates: Structure and classification of carbohydrates, monosaccharides (pentoses, hexoses), disaccharides (lactose, sucrose, maltose) and polysaccharides (starch, cellulose, glycogen and bacterial cell wall polysaccharides) explanations.	12h
2	Basics of Amino Acids and Proteins Aminoacids: Nomenclature, classification and buffering properties, zwitterionic structure, reactions of Amino acids. Proteins: Primary, secondary, tertiary and quaternary structures, protein sequencing. Factors responsible for protein folding: Anfinsen's experiment. Non-covalent interactions and S-S bridges in stabilizing the proteins, Denaturation and renaturation of proteins, molten globule, chaperones.	12h
3	Basics of Lipids & Enzymology Lipids: Classification & reaction of lipids; oils, fats, and waxes. Occurrence and properties of fatty acids, esters of fatty acids, cholesterol, phospholipids, glycolipids, sphingolipids, cerebrosides and gangliosides. Role in cell membrane. Enzymology: Classification, enzyme activity, Michaelis-Menten kinetics, LB plot, inhibition - competitive, uncompetitive, non-competitive, determination of K _i , active site, allosterism - ATCase, isoenzymes- LDH, catalytic strategies, co-enzymes and cofactors, multienzyme complexes-PDC.	12h
4	Basics of Nucleic Acids: DNA as genetic material ,Griffith ,Avery & Macleod experiments , isolation of DNA & RNA from biological sources, secondary structure of DNA, Watson and Crick model, Chargaff's rule; B and Z DNA. Features of mitochondrial, chloroplast DNA and plasmids. Secondary structure of tRNA and clover leaf model. Physiochemical properties of nucleic acids, melting of DNA, T _m ; factors affecting T _m , C ₀ t curve, classification of DNA based on C ₀ t curve.	12h

Learning Outcomes: After studying this paper the students will know –

- Chemistry of biomolecules.
- The fundamental principles in sequencing of DNA.
- Importance of biomolecules in the biological system.

References:

- Bahl, A. 2010. Advanced organic chemistry. S Chand & Company Limited.
- Berg, J. M., Tymoczko, J. L., and Stryer, L. 2006. Biochemistry: International edition. W H Freeman & Company Ltd.
- Berg, J. M., Tymoczko, J. L, and Stryer, L. 2002. Biochemistry (5th Ed.). W H Freeman.
- Mathews, P. 2002. Advanced chemistry. Cambridge low price editions. Cambridge University Press, UK.

5. Morrison, R., and Boyd, R. 1992. Organic Chemistry (6th Ed.). Englewood Cliffs, NJ: Prentice Hall.
6. Nelson, D. L., Lehninger, A. L., and Cox, M. M. 2008. Lehninger principles of biochemistry. New York :
7. Voet, D., and Voet, J. G. 2010. Biochemistry, (4th Ed.) New York: J. Wiley & Sons.

M.Sc. Biochemistry I Semester	Techniques in Biology	FCHC – Foundation Course Hard Core
Total Hours: 48	Credits: 04 (LTP - 3:1:0)	Total Marks: 15+15+70 = 100

Learning Objectives: Students should study this paper to know –

- This paper is designed to give a brief introduction to most of the techniques used in the field of biological analyses.
- Nevertheless, the topics in this paper are to be taught compendiously.

Module	Course contents	
1	<p>Biological samples: Types and preparation Study Models: <i>In vivo</i> and <i>in vitro</i> models; Microbial, Animal, Plants; choice of models; types of studies, Auxotrophs. Routes of exposure of test chemicals in animals. Culture: microbes, animal and plant cells in laboratory.</p> <p>Cell fractionation techniques: Tissue homogenization, Cell lysis techniques, extraction of cellular contents. Protein purification techniques: salting in, salting out, dialysis and ultrafiltration.</p> <p>Centrifugation: Svedberg's constant, sedimentation velocity and sedimentation equilibrium.</p> <p>Ultra centrifugation: Differential and density gradient centrifugation, centrifugal elutriation, isolation of cell organelles (e.g. Mitochondria) from biological tissue samples.</p>	12h
2	<p>Spectroscopic analysis</p> <p>Principles and applications of colorimeter, spectrophotometer, fluorimeter, multiwall plate reader. Beer-Lambert's Law and its limitations. Extinction coefficient, chromogenic and fluorescent probes, their applications. Principle of flame photometry, and X-ray crystallography, IR, ESR, NMR & Raman's spectroscopy.</p>	12h
3	<p>Chromatographic and electrophoretic techniques</p> <p>Chromatography: Principles, working and applications of paper chromatography (radial, ascending, descending and 2-D), Thin layer chromatography, Brief introduction, application of Adsorption, Ion exchange, Gel filtration, Affinity, Gas chromatography. Chromatofocusing, HPLC, UPLC and FPLC.</p> <p>Protein electrophoresis: Polyacrylamide gel electrophoresis, SDS-PAGE, IEF & 2DEF. Visualizing proteins using CBB, silver stain; glycoproteins and lipoproteins staining, Brief introduction to Zymogram and reverse zymogram;</p> <p>Nucleic acid electrophoresis: Agarose gel electrophoresis, Visualizing nucleic acids in using Ethidium bromide and UV. Fluorescence probes: SYBR green and Eeva green, Taq man, PFGE and capillary electrophoresis.</p>	12h
4	<p>Radiochemistry and Mass spectroscopy</p> <p>Isotopes: Heavy isotopes and radio isotopes, half-life, decay constant, detection and quantitation; Principle and working of GM counter and scintillation counter (solid/liquid).</p> <p>Mass spectroscopy Principle and construction of mass spectrometer. m/e, tof, MALDI and ESI. LC-MS, LC-MS-MS.</p> <p>Applications of radioactivity: Radio isotopes in biology ³H, ¹⁴C, ³²P, ¹³¹I, ³⁵S; Labeling of proteins and nucleic acids, autoradiography, pulse chase method, carbon dating.</p>	12h

Learning Outcomes: After studying this paper the students will know –

- Techniques in Biology.

- b. The fundamental principles in cell homogenization.
- c. Importance of bio analytical techniques.

References:

1. Bryce, C., and Balasubramanian, D. 2004. Concepts in Biotechnology: Hyderabad Universities Press.
2. Crueger, W., and Crueger, A. 2017. Biotechnology: a textbook of industrial microbiology. Medtech.
3. Marshall, A. G. 1978. Biophysical chemistry: principles, techniques, and applications: Wiley New York.
4. Micklos, D. A., and Freyer, G. A. 1990. DNA science; a first course in recombinant DNA technology: Cold Spring Harbor Laboratory Press.
5. Purohit, S., and Mathur, S. 1999. Drugs in Biotechnology fundamentals and applications. Purohit SS.,Ed., Maximum Publishers, India.
6. Slater, A., Scott, N., and Fowler, M. 2003. Plant Biotechnology: The Genetic Manipulation of Plants. Oxford University Press, Oxford, New York,
7. Walker, M., and Rapley, R. 2009. Route maps in gene technology. John Wiley & Sons.
8. Wilson, K., and Walker, J. 2010. Principles and techniques of biochemistry and molecular biology. Cambridge University Press.

Practical:

1. Ascending, descending and circular paper chromatography for separation of amino acids
2. TLC of amino acids (1D and 2D)
3. Column chromatography- gelfiltration
4. Gel electrophoresis- native and SDS-PAGE and estimation of molecular weight of proteins
5. Demonstration of HPLC, LC-MS, XRD and Electronmicroscopy
6. Wavelength scan of proteins and nucleic acids
7. Preparation of homogenates and mitochondria from plant and animal tissues.
8. Estimation of molar extinction coefficient of methylene blue (Beer Lambert's Law)
9. Isolation of esterase from green peas using ammonium sulphate precipitation.
10. Estimation of esterase activity using colorimetric method.

M.Sc. Biochemistry I Semester	Molecular Cell Biology	FCHC – Foundation Course Hard Core
Total Hours: 48	Credits: 04 (LTP - 3:1:0)	Total Marks: 15+15+70 = 100

Learning Objectives: Students should study this paper to know –

- The structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles.
- Cell cycle and cellular processes. Concept of cancer biology and signal transduction

Module	Course contents	
1	Organization of the cell Universal features of cells, Ultra-structure of prokaryotic and eukaryotic cells (Plants and animals), Structure of plant cell wall, Structure of cell membrane and models, functions of cell membrane, Intracellular organelles: Structure and functions of Ribosomes, Golgi apparatus; Mitochondria, Chloroplast, Lysosomes, Centrosome, Endoplasmic reticulum, Nucleus-Internal organization, Chromatin- structure and function, cellular cytoskeleton.	12h
2	Cellular processes Cell cycle and its regulation, Cell cycle check points, Molecular dynamics of cell division, interphase, Mitosis and meiosis, Cyclins and CDKs, Cell differentiation: Stem cells, Differentiation of stem cells into different cell types and organization into specialized tissues, apoptosis, necrosis & autophagy Molecular mechanisms of membrane transport active, passive and facilitated, Receptor mediated endocytosis.	12h
3	Cancer Biology Introduction, Historical account, classification, Characteristics of cancer cells, hallmark features of cancer cells, Carcinogenesis, Exogenous and endogenous carcinogens, cancer initiation, promotion and progression, Cancer cell cycle, Viruses and cancer, Oncogenes, Tumor suppressor genes with examples, cancer therapy present and future, Role of p53 in cancer. Role of phytochemicals in cancer treatment, cancer stem cells.	12h
4	Basics of Signal Transduction Extra-cellular matrix components, Cell junctions, Cell adhesion molecules, Hormones and their receptors, Cell surface receptors as reception of extra-cellular signals, Types of cell signalling, Growth factors- EGFR, VEGF, PDGF and their Signalling, signalling through G-protein coupled receptors; Second messengers in signal transduction pathways: cAMP and calcium ions (Ca ²⁺), signalling through Receptor tyrosine kinases, MAP kinase pathway, P13K -Akt pathway.	12h

Learning Outcomes: After studying this paper the students will know –

- Role of cell cycle and its regulation.
- Phytochemicals in cancer treatment and stem cells.
- Receptors of signaling pathways.

References:

- Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., and Walter, P. 2008. Molecular Biology of the Cell. (5th Ed.) New York: Garland Science.
- Cooper, G. M., and Hausman, R. E. 2013. The Cell: a Molecular Approach (6th Ed.).

Washington: ASM, Sunderland.

3. Hardin, J., Bertoni, G., Kleinsmith, L. J., and Becker, W. M. 2012. Becker's World of the Cell. Boston (8th Ed.). Benjamin Cummings.
4. Kleinsmith, L.J., and Kish, V. M. 1995. Principles of Cell and Molecular Biology (2nd Ed.) Harper Collins College Publishers, New York, USA.
5. Lodish H., and Berk A. 2016. Molecular Cell Biology (8th Ed.). New York. W H Freeman.

Practicals:

1. Microscopic examination of prokaryotic and eukaryotic cells using staining techniques.
2. Isolation of cell organelles.
3. Micrometer.
4. Cell Counting and viability.
5. Bacterial growth curve.
6. Study of mitosis in onion root tips.
7. Study of meiosis in onion flower buds.
8. Polytene chromosomes.
9. Study of chromosomes by air-dry technique

M.Sc. Biochemistry I Semester	Practical 1A (Experiments in Fundamentals of Biochemistry & Techniques in biology, Laboratory Visit)	HC – Hard Core
Total Hours: 64	Credits: 02 (LTP - 0:0:4)	Total Marks: 15+15+70 = 100

1. Distillation of water for biochemical assays.
2. Preparation buffers and solutions & Measurement of pH.
3. Determination of pKa of amino acids.
4. Estimation of λ_{max} and molar extinction coefficient (Beer Lambert's Law).
5. Isolation of starch from potatoes and estimation of purity.
6. Isolation of glycogen from chicken liver and estimation of purity.
7. Estimation of reducing sugar by DNS method.
8. Centrifugation.
9. Purification of casein from cow's milk.
10. Estimation of proteins by Lowry's method.
11. Estimation of proteins by Biuret Method.
12. Estimation of saponification of lipids.
13. Estimation of iodine value of lipids.
14. Wavelength scans of proteins and nucleic acids using a spectrophotometer.
15. Circular paper chromatography for separation of amino acids.
16. Ascending paper chromatography for separation of amino acids.
17. Descending paper chromatography for separation of amino acids.
18. 2D paper chromatography for amino acids.
19. Thin layer chromatography of amino acids (1D and 2D).
20. Column chromatography for the separation of plant pigments.
21. Gel filtration (Size exclusion chromatography).

Laboratory Visits:

22. Demonstration of native Poly Acrylamide Gel Electrophoresis (PAGE).
23. Demonstration of Sodium Dodecyl Sulphate-Poly Acrylamide Gel Electrophoresis (SDS-PAGE) and estimation of molecular weight of proteins.
24. Demonstration of High Performance Liquid Chromatography.
25. Demonstration of Liquid Chromatography Mass Spectroscopy (LC-MS).
26. Demonstration of X-Ray Diffraction crystallography (XRD).
27. Demonstration of Nuclear Magnetic Resonance (NMR).
28. Demonstration of Infra-Red Spectroscopy (IR).
29. Demonstration of Atomic Absorption Spectroscopy (AAS).

M.Sc. Biochemistry I Semester	Practical 1B (Experiments in Molecular Cell Biology & Genetics Microbiology / Genetic Engineering and Seminar.)	HC – Hard Core
Total Hours: 64	Credits: 02(LTP - 0:0:4)	Total Marks: 15+15+70 = 100

1. Microscopic examination of prokaryotic and eukaryotic cells using staining techniques.
2. Cell Counting using hemocytometer.
3. Micrometry.
4. Assessment of cell viability and cytotoxicity.
5. Preparation of liquid and solid media for growth of microorganisms
6. Isolation and maintenance of microorganisms (from soil and water) by plating, streaking and serial dilution methods, slants and stab cultures.
7. Culturing the anaerobic bacteria by candle jar method.
8. Measurement of bacterial population and growth curve by turbidometry
9. *Storage of microorganisms.*
10. Effect of temperature, pH, carbon and nitrogen sources on growth.
11. Gram stain, acid fast stain and staining for spores.
12. Assay of antibiotics and demonstration of antibiotic resistance.
13. Ultra-violet killing curve and determination of mutant types in *Saccharomyces cerevisiae*.
14. Isolation of cell organelles.
15. Study of mitosis in onion root tips.
16. Study of meiosis in onion flower buds.
17. Study of special chromosomes- B chromosomes, and sex chromosomes.
18. Determination of chiasma frequency in onion.
19. Assessment of polytene chromosomes.
20. Study of chromosomes by air-dry technique
21. Study of Mutations in *Drosophila*
22. Study of Autosomal and sex linked gene inheritance in *Drosophila*
23. To solve genetic problems on linkage, ordered and unordered tetrads

M.Sc. Biochemistry I Semester	Genetics	FCSC – Foundation Course Soft Core
Total Hours: 48	Credits: 03 (LTP - 3:1:0)	Total Marks: 15+15+70 = 100

Learning Objectives: Students should study this paper to know –

- The development of Genetics and the principles of Mendel.
- The concepts of Viral, Bacterial, Fungal & Algal genetics.
- Mutation and Mutagenesis

Module	Course contents	
1	History and developments of genetics: Principle of Genetic Transmission: Mendel's Experiments, Symbols and terminology, Principle of dominance and segregation, Principle of independent assortment, Mendelian inheritance and probability (Multiplication and Addition rules). Extensions of Mendelian Principles: co-dominance, incomplete dominance, gene interactions, multiple alleles, lethal alleles, pleiotropy, penetrance and expressivity, polygenic inheritance, linkage and crossing over, sex linked inheritance, sex limited and influenced traits, genome imprinting, extra nuclear inheritance.	12h
2	Viral Genetics: Lytic and Lysogenic cycles, Phage Phenotypes, Phenotypic Mixing, Recombination and Mapping. Bacterial Genetics: Bacterial Transformation- Types of transformation mechanisms found in prokaryotes, Bacterial Conjugation- properties of the F plasmid, F^+ x F^- mating, F' x F^- conjugation, Hfr conjugation. Fungal Genetics: <i>Neurospora</i> - Tetrad analysis and linkage detection - 2 point and 3 point crosses, chromatid and chiasma interference, Mitotic recombination in <i>Neurospora</i> . Algal Genetics: <i>Chlamydomonas</i> - unordered tetrad analysis - Recombination and Mapping. Floral meristems and floral development in <i>Arabidopsis</i> , ABC model.	12h
3	Mutation and mutagenesis: Nature, type and effects of mutations. Mutagenesis – physical and chemical mutagens, base and nucleoside analog, alkylating agents, interrelating agents, ionizing radiation. Induction and detection of mutation in microorganisms and <i>Drosophila</i> . Site directed mutagenesis and its applications. Recombination: Homologous and non-homologous recombination, Holliday model, site-specific recombination. DNA Repair: Mechanism of genetic repair- direct repair, photoreactivation, excision repair, mismatch repair, post-replicative recombination repair, Repair of double-strand breaks, SOS repair.	12h
4	Sex Determination -Sex chromosomes, Chromosomal and genetic basis of sex determination. Sex determination in <i>C.elegans</i> , <i>Drosophila</i> , human and Plant (<i>Melandrium</i>). Dosage compensation-Genic balance, Gene dose, Molecular basis of dosage compensation in <i>Drosophila</i> and man. Transposable elements - discovery in maize and bacteria, transposal elements in bacteria and bacteriophage, types and functions; Transposable elements in eukaryotes- Plants, <i>Drosophila</i> and Humans, mechanisms of transpositions.	12h

Learning Outcomes: After studying this paper the students will know –

- a. Model organisms available to study genetics.
- b. Types of DNA recombination and DNA repair.
- c. Detailed account on transposable elements and transpositions.

References:

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Robert, K., and Watson, J. D. 1999. Molecular biology of the cell. Garland Pub. Inc. New York.
2. Alberts, B., Johnson, A., Lewis, J., Rafi, M., Roberts, K., and Walter, P. 2008. Molecular biology of the cell (5th Ed.), Garland science. Taylor & Francis Group, New York, USA.
3. Atherly, A. G., Girton, J. R., and Donald, J.R. 1999. The Science of Genetics. Saunders College Publishing, Fort Worth. Texas.
4. Brooker, R.J. 2005. Genetics –analysis and principles. Addison Wesley Longman Inc., California.
5. Brown, T.A. 2000. Genetics: a molecular approach. Van Nostrand Reinhold (intn) Co., Ltd., London.
6. Buchanan, B.B., Gruissem, W., and Jones, R.L. 2010. Biochemistry and Molecular Biology of Plants. Ed. ASPP Press.USA.
7. Fairbanks, D.J., and Anderson, W.R. 1999. Genetics the continuity of Life. Brooks's/Cole Pub. California.
8. Griffith, A. J. F., Gelbart, W.M., Muller, J. H., and Lewintin, R. C. 1999. Modern Genetic Analysis. W.H. Freeman and Co. New York.
9. Hartl, D. 1991. Basic Genetics (2nd Ed.). Jones and Barlett Publisher Inc. Boston.
10. Kleinsmith, L. J., and Kish, V.M. 1995. Principles of Cell and Molecular Biology (2nd Ed.). Harper Collins College Publisher, New York, USA.
11. Lodish, H., Berk, A., Zipurasky, S. L., Matsudaira, P., Baltimore, D., and Darnell, J. 2000. Molecular Cell Biology (4th Ed.). W.H. Freeman and Co. New York, USA.
12. Randhawa, S. S. 2017. Textbook of Genetics (1st Ed.). S Vikas and Company, Jalandhar.
13. Snustad, D . P., Simmons, M. J., and Jenkins, J. R. 1997. Principles of Genetics. Hohn Wiley & sons Inc, New York.
14. Strickberger and Monroe W. 2000. Evolution (3rd Ed.). Jones & Bartlett Publisher, Inc. USA.
15. Tamarin, R. H. 2009. Principles of Genetics (7th Ed.) Tata-McGraw Hill, New Delhi.
16. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine M., and Losick, R. 2004. Molecular Biology of the Gene (5th Ed.). Pearson Education Pt. Ltd., New Delhi, India.

Practicals:

1. Replica plating technique for transfer of bacterial colonies.
2. Ultra-violet killing curve and determination of mutant types in *Saccharomyces cerevisiae*.
3. Induction of mutation
4. Isolation of streptomycin resistant strain of *E .coli* by gradient plate method.
5. Ames test
6. Study of special chromosomes- B chromosomes, and sex chromosomes.
7. Determination of chiasma frequency in onion.
8. To solve genetic problems on linkage, ordered and unordered tetrads
9. Study of Mutations in *Drosophila*
10. Study of Autosomal and sexlinked gene inheritance in *Drosophila*

M.Sc. Biochemistry I Semester	Genetic Engineering	FCSC – Foundation Course Soft Core
Total Hours: 48	Credits: 03 (LTP - 3:1:0)	Total Marks: 15+15+70 = 100

Learning Objectives: Students should study this paper to know –

- a. To understand cloning and expression vectors.
- b. Methods involved in gene manipulation and techniques of gene analysis.
- c. The vast knowledge of gene editing.

Module	Course contents	
1	Cloning and Expression vectors: Plasmids, lambda vectors, M13 Phage, cosmids, phagemids, Artificial chromosome vectors-YACs, PACs and BACs, plant and animal viruses as vectors, Transposons, Expression vectors- prokaryotic (pRSET, pET), eukaryotic (pcDNA3, pCEP), Baculovirus and Pichia vector system, plant based vectors- Ti and Ri, binary and shuttle vectors, Gene cloning: genomic cloning, c-DNA cloning.	12h
2	Gene manipulation: Restriction enzymes, restriction mapping, cloning in plasmid, Phage and cosmid vectors, insertion of foreign DNA into host cells-transformation, electroporation, Transfection transient and stable, screening methods for transformants, downstream processing of recombinant proteins, affinity tags- His-tag, GST-tag, MBP-tag, Fc-tag. Construction and screening of genomic and cDNA libraries, chromosome walking, Chromosome Jumping, BAC libraries and assembly of BACs into contigs.	12h
3	Gene analysis techniques: Hybridization techniques- Southern, Northern, South-western, Far-western, Colony hybridization, fluorescence <i>in situ</i> hybridization, molecular probes-preparation, labelling, amplification, applications, Polymerase chain reaction-Principle, primer designing, Types- RT-PCR, Realtime PCR, colony PCR, Multiplex PCR, Hot-start PCR, asymmetric PCR, Sequencing methods- chemical sequencing of DNA (Maxam and Gilberts methods and Sangers dideoxy method), automated DNA sequencing, sequencing by DE-MALDI- TOFMS, microarray. ChIP and Chip-on-chip techniques Chromogenic <i>in situ</i> hybridization, qPCR, next generation sequencing.	12h
4	Gene therapy, transgenics and Genome editing: <i>Ex vivo</i> and <i>in vivo</i> gene therapy, Vectors and other delivery systems for gene therapy, Invitro gene therapy, gene therapy of genetic diseases: eg. Neurological, metabolic disorders and cystic fibrosis, viruses for gene therapy- lentivirus, adenovirus. Gene targeting, knockout mice, genome editing by CRISPR-CAS	12h

Learning Outcomes: After studying this paper the students will know –

- a. The use of plant and animal viruses as vectors.
- b. The in-depth knowledge of techniques used in genetic engineering.
- c. The knowledge about the Ex vivo and in vivo gene therapy.

References:

1. ___Brown, T.A. 2010. Gene Cloning and DNA Analysis-An Introduction (6th Ed.). Blackwell Science.
2. Brown, T.A., 2011. Introduction to Genetics: A Molecular Approach (1st Ed.). Garland Science.
3. Desmond, S. T., and Nicholl, 2002. An Introduction to Genetic Engineering. (1st Ed.) Cambridge University Press. Cambridge.
4. Glazer, A. N., and Nikaido, H. 2007. Microbial Biotechnology Fundamentals of Applied Microbiology (2nd Ed.). Cambridge University Press.
5. Gupta, P. K. 2008. Molecular Biology and Genetic Engineering. Deep and Deep Publications, India.
6. Gupta, V. K., Schmoll, M., Maki, M., Tuohy, M., Mazutti, M. A. 2013. Applications of Microbial Engineering. CRC Press.
7. Jane, K. S. 2004 .Genetic Engineering: Principles and Methods (1st Ed.). Springer.
8. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M. 2007 .Molecular Cell Biology (6th Ed.). W H Freeman and Company, New York.
9. Maheshwari, D.K., Dubey, R.C. and Kang, S.C. 2006. Biotechnological Applications of Microorganisms. I.K. International Publishing House, New Delhi.
10. Rehm, H. J., and Reed, G. 2008. Biotechnology: Genetic Fundamentals and Genetic Engineering (2nd Ed.). Wiley India Pvt Ltd.

Practicals:

1. Salt fractionation of Yeast protein and quantification.
2. Isolation of plasmids from bacteria by agarose gel electrophoresis.
3. Preparation of competent *E. coli* cells for Bacterial transformation.
4. Induction of gene expression and purification of the induced protein from the host.
5. Amplification, Purification and separation of PCR product.
6. Determination of Proteinase activity on proteins
7. Production of recombinant protein

M.Sc. Biochemistry I Semester	Microbiology	FCSC – Foundation Course Soft Core
Total Hours: 48	Credits: 03 (LTP - 3:1:0)	Total Marks: 15+15+70 = 100

Learning Objectives: Students should study this paper to know –

- The characteristics of microbes, their taxonomy and diversity.
- The growth of microbes and their control.
- The relationship between microbes and environment.

Module	Course contents	
1	The beginning of microbiology and Microbial Characteristics Introduction to Microbiology and Microbes; History and scope of Microbiology – Hook, Antony van Leeuwenhoek and Cohn; Contribution of Pasteur and Koch. Prokaryotic cell structure, pure culture techniques; bacterial genetics: transformation, transduction and conjugation; antimicrobial resistance. Culture collection and Maintenance of cultures.	12h
2	Microbial Taxonomy and Microbial diversity Criteria for classification of bacteria; Bergy's manual, Cyanobacteria, acetic acid bacteria, lactic acid bacteria and Mycobacteria. Archaea: Halophiles, Methanogens and thermophiles. Viruses: general properties of virus, viral structure, sub-viral particles – viroids and prions. Eukarya: algae and fungi, general characteristics and outline classification.	12h
3	Microbial Growth and Control Microbial growth: Growth curve, batch and continuous culture system culture, factors affecting growth like temperature, acidity, alkalinity. Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, Microbes and environment: Nutrient cycles (carbon and nitrogen cycle); microbial communication system; quorum sensing, prebiotics and probiotics.	12h
4	Beneficial and Harmful effects of Microorganism Beneficial aspects of microbes and their metabolites in food industry, Bioremediation. Important microbial diseases of Plants caused by fungi, bacteria and viruses. Important infectious diseases of humans, caused by bacteria, protozoa and viruses - tuberculosis, malaria and AIDS. Emerging and resurgent infectious diseases, SARS-COV 2 structure and virulence of virus. Host-Microbe interaction (pathogen interaction, microbiome analysis method.)	12h

Learning Outcomes: After studying this paper the students will know –

- Identification of bacteria through Bergy's manual.
- The fundamentals of antibiotics.
- The beneficial and harmful effects of microorganisms.

References:

- Matthai, W., Berg, C. Y., and Black, J. G. 2005. Microbiology, Principles and Explorations.

Boston, MA: John Wiley & Sons.

2. Parker, N, Schneegurt, M., Thi Tu, A. H, Forster B. M., Lister P. 2017. Microbiology. Openstrax.
3. Pelczar, M. J., et al., 2001. Microbiology (5th Ed.). New York: McGraw-Hill.
4. Rekadwad, B, 2020. Microbial Systematics, Taxonomy, Microbial Ecology, Diversity. CRC Press.
5. Willey , J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., and Willey, J. M. 2011. Prescott's Microbiology. Willey New York, McGraw-Hill.

Practical

1. Preparation of liquid and solid media for growth of microorganisms
2. Isolation and maintenance of organisms by plating, streaking and serial dilution methods, slants and stab cultures, storage of microorganisms
3. Isolation of pure cultures from soil and water
4. Microbial growth curve
5. Measurement of bacterial population by turbidometry and serial dilution methods.
6. Effect of temperature, pH, carbon and nitrogen sources on growth.
7. Microscopic examination of bacteria, yeast and molds & study of organisms by gram stain, acid fast stain and staining for spores.
8. Assay of antibiotics and demonstration of antibiotic resistance.
9. Biochemical characterization of selected microbes.

M.Sc. Biochemistry II Semester	Molecular Biology	FCHC – Foundation Course Hard Core
Total Hours: 48	Credits: 04 (LTP - 3:1:0)	Total Marks: 15+15+70 = 100

Learning Objectives: Students should study this paper to know –

- To understand biological activities and metabolism at DNA and protein level
- The course gives an in-depth insight into the molecular aspects of life - the central dogma.
- It explains molecular aspects of genes and its regulation- genome- gene expressions heredity- recombination- protein synthesis- molecular basis of diseases- mutations genetic analysis etc.

Module	Course contents	
1	<p>Genome organization: : Prokaryotic and eukaryotic genome organization, central dogma, structural organization of chromosome, structure and functions of DNA & RNA, Biochemical evidences for DNA as genetic material.</p> <p>DNA: Chemistry of DNA, Forces stabilizing DNA structure, Physical Properties of Ds DNA (UV absorption spectra Denaturation and renaturation), chemical that react with DNA, Interaction with small ions, DNA binding motifs: Zinc finger, leucine zipper, helix-turn- helix others motifs, DNA binding and kinks.</p>	08h
2	<p>DNA topology: Supercoiled form of DNA, Biology of supercoiled DNA, DNA topoisomerases, effect of supercoiling on structure of DNA and role of supercoiling in gene expression and DNA replication.</p> <p>DNA Replication: Characteristics and functions of bacterial DNA polymerases I, Mechanism of prokaryotic DNA replication, models of replications in prokaryotes. Fidelity of replication, Eukaryotic DNA polymerases and mechanism of replication. Replication of viral DNA, DNA replication in telomeric regions, Telomerases, mechanisms of action of topoisomerase I and II ,Models of DNA replication, Inhibitors of replication.</p>	12h
3	<p>Transcription: Characteristics and function of bacterial RNA polymerases Eukaryotic RNA polymerases, mechanism of transcription and regulation. transcription factors, Stringent response. Post transcriptional modifications of mRNA mechanism of splicing, Processing of tRNA and rRNA. Inhibitors of transcription. Mechanism of action of ribozymes ,</p> <p>Translation: Structure and role of tRNA in protein synthesis, ribosome structure, basic feature of genetic code and its deciphering, translation (initiation, elongation and termination in detail in prokaryotes as well as eukaryotes), Post translational processing, Control of translation in eukaryotes (Antisense RNA, Heme and interferon).</p>	14h
4	<p>Regulation of Gene expression in prokaryotes and eukaryotes: Positive and negative regulation. lac-, ara-, his- and trp- operon regulation; antitermination, global regulatory responses; Regulation of gene expression in eukaryotes: Transcriptional, translational and processing level control mechanisms.</p> <p>Protein localization&Gene Silencing: Export of secretory proteins- signal hypothesis, transport and targeting of proteins to mitochondria, chloroplast,</p>	14h

peroxisomes, Gene Silencing: Definition, types, RNAi pathway, shRNA & CRISPR-CAS.

Non coding RNA: coding and non-coding RNA, types of ncRNA : Short ncRNA (mi RNA, Sn RNA, Pi RNA, t-RNA & it's fragments, SnoRNA) long ncRNA ,functional significance of ncRNA

Learning Outcomes: After studying this paper the students will know –

- a. The idea about the principles behind molecular biology.
- b. Understand the molecular tools and its application in basic research and applied research in various fields of life sciences.

References:

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J. D.1994. Molecular Biology of the Cell. Garland Science, New York.
2. Cooper, G.M. 1997.The Cell: A molecular approach, ASM Press, USA.
3. Darnell, J. Lodish, H. and Baltimore, D. 1990. Molecular Cell Biology. Scientific American Books Inc. NY.
4. Elliott, W. H., and Elliott, D. C. 2006. Biochemistry and Molecular Biology (3rd Indian Ed.). Oxford University Press, Oxford.
5. Garrett, R.H. and Gresham, C.M.1995. Molecular aspects of Cell Biology, International edition, Saunders College Publishing.
6. Karp, G. 1996.Cell and Molecular Biology concepts and experiments, John Wiley and Sons Inc. NY.
7. Lodish, H., Baltimore, D., Berk, A., Zipursky, B.L., Mastysdaira, P., and Darnell, J. 2004. Molecular Cell Biology, Scientific American Books Inc. NY.
8. Mathews, C. K, Van Holde, K. E., Ahern, K. G. 2000. Biochemistry (3rd Ed.) Pearson education.
9. Nelson, D. L., Cox, M. M. 2005. Lehninger. Principles of Biochemistry (4th Ed.). W H Freeman Co.
10. Old, R.W., Primrose, S.B. 1993.Principles of gene manipulation - An introduction to genetic engineering (7th Ed.). Blackwell Scientific Publications.
11. Research/Review articles:
 - i. Anderson, P. and Ivanov, P., 2014. tRNA fragments in human health and disease. FEBS letters, 588(23), pp.4297-4304
 - ii. Basto, A. P., et al., 2021. Micro RNAs in Tfh regulation: Small molecules with a big impact. European Journal of Immunology, 51(2), 292-295
 - iii. Crick, F. H. 1958. On protein synthesis. In Symp Soc Exp Biol (Vol. 12, No. 138-63, p. 8).
 - iv. Karakar, D., et al., 2021.The Role of Lnc RNAs in translation. Non coding RNA 7 (1):16. .
 - v. Langston, L. D., et al., 2006. DNA replication: keep moving and don't mind the gap. Molecular cell, 23(2), 155-160.
 - vi. Mleczko, A. M., et al. 2014. Ex-translational function of tRNAs and their fragments in cancer. Acta Biochimica Polonica, 61(2).

Practicals

1. Estimation of DNA by diphenyl amine method.
2. Estimation of RNA by orcinol method.
3. Isolation of Genomic DNA from yeast cell, Determination of purity and concentration of isolated DNA using spectrophotometer and agarose gel electrophoresis.
4. Isolation of Plasmid DNA and agarose gel electrophoresis.
5. Determination of RNase activity
6. Isolation of RNA & analysis using Bleach Gel electrophoresis
7. Restriction digestion of plasmid and analysis
8. DNA ligation
9. Transformation and screening
10. Polymerase chain reaction

M.Sc. Biochemistry II Semester	Metabolism Of Carbohydrates	HC – Hard Core
Total Hours: 48	Credits: 04 (LTP - 3:1:0)	Total Marks: 15+15+70 = 100

Learning Objectives: Students should study this paper to know –

- The basics of metabolism.
- Role of carbohydrates in metabolism.
- Interactions among the metabolic enzymes

Module	Course contents	
1	Introduction: Catabolism, anabolism, and amphibolic pathways. Energy Utilization: I, II and III laws of thermodynamics. Enthalpy, entropy, free energy and chemical equilibrium. High energy compounds: Energy currency, ATP, ADP, creatine phosphate, phosphoenol pyruvate as energy rich compound.	12h
2	Catabolism and Anabolism of Carbohydrates Cellular ingestion of glucose, glycolysis, energetics regulation. Pathways of utilization of pyruvate-lactate, ethanol, gluconeogenesis, regulation, Cori cycle, glucose paradox, citric acid cycle and its regulation, energetics, anaplerosis, glyoxylate cycle. HMP shunt pathway, inter conversion of hexoses. Utilization of non-glucose sugars. Biosynthesis of sucrose, lactose, starch and glycogen.	12h
3	Mitochondrial electron transport: Entry of reducing equivalents for oxidation; malate-aspartate shuttle, glycerol phosphate shuttle. Organization of respiratory chain complexes, structure and function of the components; Fe-S proteins, cytochromes, Q cycle, proton transfer, P/O ratio, respiratory control, oxidative phosphorylation, uncouplers and inhibitors, sequence of electron carriers based on red-ox potentials. ATP synthesis, ATP synthase complex, binding change mechanism, proton motive force, Mitchell's hypothesis. Substrate level phosphorylation, futile cycles and their application.	12h
4	Hormonal regulation of glucose metabolism: Effect of hormones on carbohydrate metabolism; insulin, glucagon, catecholamines, growth hormones, corticosteroids and thyroid hormones in different tissues. Secretion of Insulin and glucagon in response to various stimuli (Fasting, food, intestinal hormones etc.) Role of Hormones in the regulation of carbohydrate metabolism: HPA axis. Adrenal gland and pancreatic hormones Disorders of carbohydrate metabolism: diabetes mellitus, classification and clinical diagnosis.	12h

Learning Outcomes: After studying this paper the students will know –

- Chemistry of carbohydrate metabolism.
- The fundamental thermodynamic principles in metabolism.
- Importance of carbohydrate metabolism.
- Role of hormones in the regulation of carbohydrate metabolism.

References:

- a. Berg J.M., Tymoczko J.L. and Stryer L. (2002) Biochemistry (5th Edition). International edition: WH Freeman & Company Limited
- b. Devlin T.M. (2020). Textbook of biochemistry: with clinical correlations (8th Edition). J. Wiley & Sons.
- c. Nelson D.L., Lehninger A.L. and Cox M.M. (2008) Principles of Biochemistry (12th Edition). Macmillan.
- d. Voet D. and Voet J.G. (2010) Text book of Biochemistry (4th Edition). New York: J. Wiley & Sons

Practical

1. Estimation of Blood glucose: fasting, post prandial, random
2. Isolation of mitochondria from the animal tissues and estimation of Succinate dehydrogenase, citrate synthase, and MTT reduction.

M.Sc. Biochemistry II Semester	Bioorganic and Bioinorganic Chemistry	HC – Hard Core
Total Hours: 48	Credits: 04 (LTP - 3:1:0)	Total Marks: 15+15+70 = 100

Learning Objectives: Students should study this paper to know –

- The basics in chemistry.
- To understand the organic reactions.
- Different types of heterocyclic compounds

Module	Course contents	
1	Bonding: Covalent bond; coordinate bond; coordinate bond formation in transition metals. Bonding of iron in hemoglobin and cytochromes, cobalt in Vit B12, magnesium in chlorophyll. Special properties of water; Structure and bonding. Crystal field theory; Ligand field theory and Valence bond theory. Chelators; types of ligands and complexes.	12h
2	Electrolytes, Non-Electrolytes and Electrodes Osmotic pressure, vapor pressure, osmometer, Donnan membrane equilibrium. Hydrogen electrode, electrode potential, and redox potential.	12h
3	Stereochemistry: Importance of stereochemistry, position and order of groups around carbon. Geometric and optical isomerism; absolute and relative configuration. Symmetry view of chirality, relation between chirality and optical activity, representation of chiral structures by Fischer. Structure and stereochemistry of sugars and amino acids; anomer, epimer, diastereomer, stereoisomer, D and L, (+) and (-), R and S.	12h
4	Mechanism of organic reactions and Heterocyclic compounds: Intermediates and rearrangements in organic reaction. Reaction energetic. Classification of rearrangement reactions. Reaction rates, order and molecularity of reaction. Mechanisms and stereochemistry of substitution (electrophilic and nucleophilic - s_N1 and s_N2 reactions) addition, elimination and rearrangement reactions. Mechanisms of ester hydrolysis. Property of aromaticity and resonance. Heterocyclic Compounds: Chemistry of furan, indole, thiazole, pterine, pteridine, isoalloxazine, pyrrole. Chemistry of porphyrins and heme and their biological importance.	12h

Learning Outcomes: After studying this paper the students will know –

- The basics in metabolic reactions.
- Different types of heterocyclic compounds and their biological role.

References:

- Bahl A. (2010) Advanced organic chemistry (22nd Edition). S Chand & Company Limited.
- Mathews P. (2002) Advanced chemistry (5th Edition). Cambridge low price editions. Cambridge University Press UK.

c. Morrison R. and Boyd R. (1992). Organic Chemistry (6th edition). Englewood Cliffs, NJ: Prentice Hall.

<p align="center">M.Sc. Biochemistry II Semester</p>	<p align="center">Practical 2A (Experiments in Molecular Biology; Bioorganic & Bioinorganic chemistry; Laboratory visits)</p>	<p align="center">HC – Hard Core</p>
<p>Total Hours: 64</p>	<p>Credits: 02(LTP - 0:0:4)</p>	<p>Total Marks: 15+15+70 = 100</p>

1. Isolation of Genomic DNA from yeast cells and determination of purity.
2. Estimation of DNA by diphenyl amine method.
3. Isolation of RNA from yeast or plant cells.
4. Estimation of RNA by orcinol method.
5. Restriction digestion of DNA and agarose gel electrophoresis.
6. Determination of RNase activity
7. Restriction digestion of plasmid and analysis
8. Polymerase Chain Reaction.
9. Estimation of Phosphate ions using Fiske-Subbarow method.
10. Estimation of calcium.
11. Estimation of Iron using Wong's method.
12. Synthesis and purification of aspirin.
13. Estimation of polyphenols from plant samples.
14. Estimation of anthocyanins from plant samples.
15. Study tour to Molecular Biology based industries and institutes.

M.Sc. Biochemistry II Semester	Practical 2B (Experiments in Metabolism of Carbohydrates and lipids;Seminar)	HC – Hard Core
Total Hours: 64	Credits: 02(LTP - 0:0:4)	Total Marks: 15+15+70 = 100

Practical 2B

1. Estimation of Blood glucose: fasting, post prandial, random
2. Isolation of mitochondria from the animal sources and MTT reduction assay.
3. Estimation of mitochondrial enzymes : Succinate Dehydrogenase (ETC complex II).
4. Estimation of mitochondrial enzymes : Citrate Synthase.
5. Isolation of phospholipids and neutral lipids from hen yolk.
6. Estimation of phospholipids and neutral lipids using thin layer chromatography.
7. Estimation of neutral lipids (cholesterol) using Zak's method.
8. Estimation of triglycerides.
9. Estimation of HDL, LDL.
10. Assessment of membrane stability of RBCs.
11. Estimation of a keto acid.
12. Activity of lipases.
13. Estimation of acid value of lipids.
14. Estimation of peroxide value of lipids.

M.Sc. Biochemistry II Semester	Metabolism of Lipids	SC – Soft Core
Total Hours: 48	Credits: 03(LTP - 3:1:0)	Total Marks: 15+15+70 = 100

Learning Objectives: Students should study this paper to know –

- The basics of metabolism.
- Role of lipids in metabolism.
- Interactions among the metabolic enzymes.

Module	Course contents	
1	Phospholipids, TG and Fatty acid degradation: Degradation of triacylglycerols, phospholipids and sphingolipids and regulations; lipase, hormone sensitive lipase, phospholipases and sphingomyelinase. β -oxidation Knoop's experiment, saturated and unsaturated fatty acids. Regulatory aspects. Oxidation: α , β and γ oxidation. Energetics and biosynthesis of fatty acids; fatty acid synthetase complex, chain elongation and desaturation. Pathways in plants and animals, conversion of linoleate to arachidionate. Regulatory aspects.	12h
2	Cholesterol synthesis, degradation, and regulations: Metabolism of circulating lipids; chylomicrons, HDL, LDL and VLDL. Reverse cholesterol transport by HDL. Oxidized lipids and their metabolism, Mechanism of foam cell formation. Obesity, and mechanisms, exercise and regulation of energy metabolism.	12h
3	Phospholipid biosynthesis and regulations: Denovo pathway and inter conversion, biosynthesis of phospholipids, sphingolipids, ether lipids and glycolipids. Degradation and biosynthesis of gangliosides and cerebroside. Biosynthesis of prostaglandins, thromboxanes, leukotrienes, and lipoxins. Role of Hormones in the regulation of lipid metabolism: HPA axis. Adrenal gland and pancreatic hormones.	12h
4	Lipid mediators: Eicosanoids, prostaglandins, leukotrienes, prostacyclins, thromboxanes, DAG, ceramide and PAF. Role of anti-inflammatory drugs and eicosanoids. Integration of metabolic pathways: Integration of carbohydrate and lipid metabolism, and their regulation and manipulation.	12h

Learning Outcomes: After studying this paper the students will know –

- Chemistry of lipid metabolism. .
- Importance of lipid metabolism.
- Role of hormones in the regulation of lipid metabolism.

References:

- Berg J.M., Tymoczko J.L. and Stryer L. (2006). Biochemistry: international edition: WH Freeman & Company Limited.

- b. Devlin T.M. (2020). Textbook of biochemistry: with clinical correlations (8th Edition). New York: J. Wiley & Sons.
- c. Nelson D.L., Lehninger A.L. and Cox M.M. (2008). Principles of biochemistry: Macmillan.
- d. D. and Voet J.G. (2010). Biochemistry (4th Edition). New York: J. Wiley & Sons.

Practical

1. Isolation of phospholipids and neutral lipids from hen yolk.
2. Estimation of phospholipids, neutral lipids, HDL, LDL.
3. Membrane stability of RBCs.
4. Estimation of a keto acid.

M.Sc. Biochemistry II Semester	Molecular Diagnostic	SC – Soft Core
Total Hours: 48	Credits: 03(LTP - 3:1:0)	Total Marks: 15+15+70 = 100

Learning Objectives: Students should study this paper to know –

- The course focuses on learning and understanding how the various molecular techniques that were studied can be developed and utilized in diagnosis.
- The course explains common analytical techniques and molecular techniques related to the development and use of diagnostics.
- Students learn about the clinical applications of molecular diagnostic in patients with infectious disease.

Module	Course contents	
1	Introduction and History of diagnostics: Introduction and History of diagnostics of diseases, mode of infection, types of infectious diseases, philosophy and general approach to clinical specimens. genetic basis of diseases, inherited diseases. Infection – mode of transmission in infections, factors predisposing to microbial pathogenicity, inborn errors of metabolism. Traditional disease diagnosis methods: Diagnosis of infectious diseases caused by bacteria, fungi, viruses, protozoa and Helminthes, Philosophy and general approach to clinical specimens, Sample collection- method of collection, transport and processing of samples, Interpretation of results, Normal microbial flora of the human body, Host - Parasite relationships.	08h
2	Molecular techniques for diagnosis Basics and Implication of Molecular techniques in Genome resolution, detection and analysis of pathogen causing disease : PCR, Real-time; Multiplex; FISH; RFLP; DGGE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray data normalization & analysis; molecular markers: 16S rRNA typing; MALDITOF-MS; Metabolite profile for biomarker detection the tissues in various disorders by making using LCMS & NMR technological platforms. Biochemical tests & Immunoassays: Detection and quantification of biochemical parameters Types: RIA, ELISA, Chemiluminescent IA, FIA and specific applications; Immunohistochemistry – principle and techniques. Different Levels of Biosafety, Containment.	14h
3	Major Metabolic & Genetic disorders: Traditional methods for the diagnosis of metabolic errors (Diabetes Type 1 & Type 2, hyperthyroidism & Hypothyroidism). Disease due to genetic disorders (Sickle cell anemia & Cystic fibrosis). Identifying human disease genes., Methods available for the diagnosis of genetic diseases and metabolic disorders. Blood (formation, composition, function and pathology of blood disorders (haemoglobinopathies, hemophilia), Muscle disorders (Duchene muscular dystrophy-DMD, Becker's muscular dystrophy-BMD, spinal muscular atrophy-SMA), Bone disorders (Osteogenesis imperfecta, Rheumatoid arthritis), Skin disorder (Muir-Torre syndrome), Eye disorder (Retinitis pigmentosa). Neonatal and Prenatal disease diagnostics. Gender identification using amelogenin gene locus. Amplification of Y chromosome specific Short Tandem Repeats (Y-	12h

	STR). Analysis of mitochondrial DNA for maternal inheritance, Karyotyping & characteristics of Karyotyping.. Molecular diagnosis for early detection of cerebral palsy, Down syndrome etc.	
4	<p>Cancer diagnosis: Molecular Oncology Tests, Analysis of the Expression of Multiple Genes and Cancer Prognosis, Analysis of Lymph Nodes to Detect Metastasis of Breast Cancer, Screening for Colorectal Cancer: Stool-Based DNA Screening, Leukemias and Lymphomas, DNA Methylation Tests and Cancer, Predicting Risk of Developing Cancer.</p> <p>Personalized Medicine: Pharmacogenomics and Companion Diagnostics, Cytochrome P450 and Drug Metabolism, Targeted Cancer Therapies and Companion Diagnostics Tests, Testing for HER2/neu Overexpression in Breast Cancer, Testing for Epidermal Growth Factor Receptor (EGFR), UGT1A1 Genetic Variants, Pharmacogenetics and Response to Antiretroviral Therapy, Thiopurine Methyltransferase and Metabolism of Thiopurine Drugs</p>	14h

Learning Outcomes: After studying this paper the students will know –

- a. The student will get an idea about the concept of molecular diagnosis and underpinning the successful application of gene therapy or biologic response modifiers as well they can find their future focus in biotechnology companies developing and marketing Diagnostic kits.

References:

- a. Carl A.B., Edward R.A. and David E.B. (2007): Tietz Textbook of Clinical Chemistry and Molecular Diagnosis (5th Edition). Elsevier.
- b. Coleman W.B. (2006). Molecular Diagnostics for the Clinical Laboratorian. Humana Press.
- c. Coleman W.B. and Tsongalis G.J. (2006). Molecular diagnostics: for the clinical laboratorian. Springer Science & Business Media.
- d. David E.B., Edward R.A. and Carl A.B. (2007). Saunders Group. Fundamentals of Molecular Diagnostics. Springer.
- e. Greenwood D.S., and Peutherer J. (1997). Medical Microbiology (6th Edition). Elsevier.
- f. Lele B. and Maribeth F. (2007). Molecular Diagnostics: Fundamentals, Methods & Clinical applications. F. A. Davis company.
- g. Leonard D.G., Bagg A., Caliendo A.M., Deerlin V.M. and Kaul K.L. (2007). Molecularpathology in clinical practice (pp. 411-424). Springer
- h. McPherson R.A. and Pincus M.R. (2017). Henry's Clinical Diagnosis and Management by Laboratory Methods. Elsevier Health Sciences.

Research articles:

- a. Egger G., Liang G., Aparicio A. and Jones P.A. (2004). Epigenetics in human disease and prospects for epigenetic therapy. Nature, 429, 6990, 457-463.
- b. Said D. (2013). Cancer Diagnosis, Treatment and Therapy. J Carcinogene Mutagene S14: 007, 1-3.

Practicals:

1. Hormone assay for thyroid (TSH, T3, T4)
2. Isolation of Genomic DNA from Spleen or Liver ,
3. Quality / Quantity checking of Nucleic acids by UV Spectrophotometer
4. Agarose Gel Electrophoresis
3. Isolation of Metagenome (sediment/soil).
4. Qualitative detection of HBsAg in human serum or plasma.using ELISA.
5. Nucleic acid labelling and Southern Hybridization.
6. RNA isolation &PAGE.
7. Culture independent analysis of microbes by DGGE(Denatured Gradient Gel Electrophoresis).
8. Molecular diagnosis of parasitic disease.
9. Identification of human bacterial pathogens by Polymerase chain reaction.
10. Demonstration of Karyotype analysis.

M.Sc. Biochemistry II Semester	Fundamentals of Biochemistry and its applications (For students of other disciplines)	OE – Open Elective
Total Hours: 48	Credits: 04(LTP - 3:1:0)	Total Marks: 15+15+70 = 100

Learning Objectives: Students should study this paper to know –

- a. The basics of biochemistry.
- b. Human physiology.
- c. Nutritional importance.

Module	Course contents	
1	Introduction: Biological sciences; Cellular structure, structural variation among plants, animals and microbes. Organelles and their functions. Embryology: gametes, fertilization, zygote, organogenesis. Biochemical reactions, types. Variation among plants and animals.	12h
2	Human Physiology: Blood: Composition, cell types red blood cells and white blood cells and their function. Hemostasis, blood clotting, digestion of clot, anticoagulants, blood volume, blood pressure and serum enzymes. Respiratory System: Lungs, structure and functions, exchange of gases. Excretory System: Ultra structure of the nephron, formation of urine. Hepatobiliary System: Anatomy of the liver, cells types.. Secretory and excretory function and formation of bile. Digestive System: GI tract, digestion and absorption of carbohydrates, proteins and lipids. Function of HCl. Muscle physiology: Skeletal muscle and smooth muscle, muscle proteins. Hormones: Endocrine organs and exocrine organs and their significance.	12h
3	Nutrition and Biomolecules: Small molecules: sugars, amino acids, nucleotides, lipids. Macromolecules: polysaccharides, proteins, nucleic acids. Carbohydrates: Dietary sources, dietary fiber, essentiality of carbohydrates. Proteins: Essential amino acids, nutritional classification of proteins, supplementary value of proteins, protein malnutrition. Fats: Sources, invisible fat, essential fatty acids, PUFA. Vitamins: Classification, source, deficiency symptoms Fat soluble and water soluble vitamins. Minerals and Water metabolism: Macro and micro nutrients, sources, requirements, functions and deficiency symptoms. Water metabolism; distribution in body, water balances, factors affecting water balance.	12h
4	Biochemistry and Society: Implications in health and disease: Diabetes Hyper tension, Hypotension Gouti arthritis, Immunology: Historical development and milestones in immunology Vaccines and Vaccination. Toxicity: Xenobiotics, heavy metals, pesticide poisoning. Discussion, demonstration, laboratory visits.	12h

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Learning Outcomes: After studying this paper the students will know –

- a. Importance of biochemistry.
- b. Application of biochemistry knowledge in the society.

References:

- a. Berg J.M., Tymoczko J.L. and Stryer L. (2006). Biochemistry: international edition: WH Freeman & Company Limited.
- b. Chatterjee C.C. (2017). Human physiology: Medical Allied Agency: CBS Publishers and Distributors Pvt. LTD.
- c. Devlin T.M. (2020). Textbook of biochemistry: with clinical correlations (8th Edition). New York: J. Wiley & Sons.
- d. Guyton A.C. and Hall J.E. (2006). Text book of Medical Physiology. Elsevier India Pvt. Ltd. New Delhi.
- e. Murray R., Granner D., Mayes P. and Rodwell V. (2003). Harper's illustrated biochemistry (LANGE basic science): McGraw-Hill Medical.
- f. Nelson D.L., Lehninger A.L. and Cox M.M. (2008). Principles of biochemistry: Macmillan.
- g. Purohit S. and Mathur S. (1999). Drugs in Biotechnology fundamentals and applications. Maximillan publishers, India.
- h. Voet D. and Voet J.G. (2010). Biochemistry (4th Edition). New York: J. Wiley & Sons.

M.Sc. Biochemistry III Semester	Immunology	FCHC – Foundation Course Hard Core
Total Hours: 48	Credits: 04(LTP - 3:1:0)	Total Marks: 15+15+70 = 100

Learning Objectives: Students should study this paper to know –

1. Role of immune system in maintaining health
2. Cellular and molecular basis of immune responses
3. How immune responses are triggered and regulated

Module	Course contents	
1	<p>Over view and Types of immunity:</p> <p>Innate immunity: anatomic barriers, physiologic barriers, phagocytic barriers, microbial antagonism, acute phase reactants, anti-microbial peptides, interferons, inflammation, Pattern Recognition Receptors (PRRs), Pathogen Associated Molecular Patterns (PAMPs) and Damage Associated Molecular Patterns (PAMPs). Complement system: components, pathways of activation and biological consequences.</p> <p>Acquired immunity: Active (Naturally acquired and artificially acquired), Passive (Naturally acquired and artificially acquired), Adoptive immunity, Humoral and Cell mediated immune response</p> <p>Tissues of immune system: Structural organization and functions of Lymphatic system, Primary lymphoid organs (Bone marrow, Thymus) Secondary lymphoid organs and tissues (Spleen, Lymph node, Tonsils, Adenoids, Peyer’s patches, Lamina propria, Mucosa-associated lymphoid tissue, Gut-associated lymphoid tissue).</p> <p>Cells of the immune system: Hematopoiesis, Biology, Development and Functions of PMNLs, NK cells, Macrophages, T-Lymphocytes, B-Lymphocytes, Dendritic cells</p>	14h
2	<p>Antigens, and Antibodies: Antigens, Immunogens and Haptens, Factors influencing immunogenicity, adjuvants, epitopes, Structure and functions of immunoglobulins, Synthesis of immunoglobulins, Genetic basis of immunoglobulin diversity.</p> <p>MHC molecules: Types, structure, diversity and functions</p> <p>Antigen recognition: Thymus dependent and independent Antigens, Clonal selection and immunological memory of B and T cells, Antigen processing and presentation (Endogenous pathway, Exogenous pathway, Cross presentation), Superantigens.</p> <p>Monoclonal Antibodies: Hybridoma technology and production of mAbs, types, and applications. Advantages and disadvantages of mAbs in therapy.</p>	12h
3	<p>Immune System in Health and Disease: Immunological Tolerance and Autoimmunity, Autoimmune Diseases (Organ specific autoimmune diseases-Graves’ disease, Myasthenia Gravis, Systemic autoimmune diseases-Multiple Sclerosis, Rheumatoid Arthritis, Systemic Lupus Erythematosus), Immunosuppression, Hypersensitivity (Type I, II, III & IV).</p> <p>Vaccines and Vaccination: Principles of vaccination, Immune response to vaccines (Primary and Secondary response), Whole-Organism vaccines, Purified macromolecules as vaccines, Recombinant vaccines, DNA vaccines, Multivalent subunit vaccines and Edible vaccines, Vaccine safety, Reverse vaccinology. Overview of COVID-19 vaccines.</p> <p>Primary & Secondary Immuno-Deficiency Disorders: Primary: Wiscott-Aldrich</p>	12h

	syndrome, Severe combined immunodeficiency disease (SCID), DiGeorge syndrome, Ataxia-telangectasia, Leucocyte adhesion defects, Chronic granulomatous disease, X-linked agammaglobulinemia, Complement deficiencies. Gammopathies (Multiple myeloma). Secondary: AIDS, Malnutrition, Drug regimen, Diabetes, Chronic infection	
4	<p>Clinical Immunology: Transplantation of tissues and organs: Nomenclature of transplantations, Transplantation reactions, HvG and GvH. Exception from rejections, Major and minor blood groups, Blood transfusion, tissue typing, Kidney and bone marrow transplantations. Immunosuppressive drugs. Tumor immunology: Neoplasms, tumor-associated antigens, immune response to tumor antigens, immunologic factors favoring tumor growth, immune surveillance, Tumor necrosis factor α and β. Metastatic processes, Immunodiagnosis, Antitumour drugs, Immunotherapy.</p> <p>Immunological Techniques: <i>In vitro</i> antigen-antibody reactions, serotyping, agglutination, complement fixation, immunoprecipitation, Immunodiffusion, ELISA, RIA, IHC, Immunoelectrophoresis.</p>	10h

Learning Outcomes: After studying this paper the students will know –

- Organs, tissues, cells and molecules of the immune system
- The immunological methods used to detect the disease
- How the knowledge of immunology can be transferred into clinical decision-making through case studies presented in class.

References:

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 20. Ramesh, S. R. 2016. Immunology. Mc Graw Hill Education India Pvt. Ltd.
 21. Richard C. and Geoffrey S. (2003). Immunology: A short course (6th Edition). Willey Blackwell.
 22. Voet D. and Voet J.G. (2010). Text book of Biochemistry (4th Edition). New York: J. Wiley & Sons

Practical:

1. Purification of IgG.
2. Slide agglutination test/ Blood grouping.
3. Immunoprecipitation test- Ouchterlony double diffusion.
4. Immunofluorescence for localization of an antigen.
5. ELISA for quantification of an antigen.
6. Western blotting and detection.
7. Complement fixation
8. Clinical laboratory visits

M.Sc. Biochemistry III Semester	Enzymology	HC – Hard Core
Total Hours: 48	Credits: 04(LTP - 3:1:0)	Total Marks: 15+15+70 = 100

Learning Objectives: Students should study this paper to know –

- The basics of enzymology.
- Mechanism of action of enzymes.
- Different types of inhibition.

Module	Course contents	
1	General aspects: Nature of enzymes, localization, isolation, purification and characterization of enzymes. Criteria of purity of enzymes, fold purity. Nomenclature and IUB classification of enzymes. Enzyme specificity, specific activity, assay methods; coupled enzyme assays, continuous, end point and kinetic assay. Units of enzyme activity, IU and Katal.	12h
2	Enzyme kinetics: Michaelis-Menten equation for uni substrate reactions, initial velocity approach, steady state approach. V_{max} , K_m and their significance. Linear transformation of Michaelis-Menten equation; Lineweaver-Burk plot, Eadie-Hofstee, Wolf and Cornish-Bowden. Scatchard plot. Rate of a reaction, order and molecularity. I order reaction kinetics. Rectangular hyperbola, Michaelis-Menten equation as rectangular hyperbola, linear transformation, calculation of slope, intercept. Reversible and irreversible inhibition; competitive, non competitive, uncompetitive product inhibition and suicide inhibition. Determination of K_i and K_d . Bisubstrate reaction: Cleland's notation with examples of ordered, ping-pong, and random reactions. General rate equation.	12h
3	Cooperativity; Isozymes and Multifunctional enzymes Binding of ligands to macromolecules; Scatchard plot, positive and negative cooperativity. Oxygen binding to hemoglobin. Hill equation, homotropic and heterotropic effectors, aspartyl trans carbamylase as an allosteric enzyme. Metabolic regulation of enzyme activity: Feedback regulation, fine control of enzyme activity. Isoenzymes; LDH, multifunctional enzymes (DNA polymerase) and multi enzyme complex (PDC).	12h
4	Mechanisms of enzyme catalysis: Active site structure; methods of determining active site structure. Isolation of ES complex, affinity labeling, chemical modification studies, site directed mutagenesis. Nature of enzyme catalysis: Transition state theory, proximity and orientation, orbital steering, acid base catalysis, covalent catalysis, metal ion catalysis, nucleophilic and electrophilic catalysis, intramolecular catalysis, entropy effects. Effect of temperature and pH on enzyme catalysed reaction. Fast reactions - Stopped flow, temperature jump method with examples of enzymes. Mechanisms of action of specific enzyme: Chymotrypsin; zymogen activation, acid-base catalysis, charge relay network. Lysozyme, alcohol dehydrogenase, ribonuclease, carboxypeptidase A, RNA as an enzyme, abzymes, coenzymic action of NAD^+ , FAD, TPP, PLP, Biotin, CoA, folic acid and lipoic acid.	12h

Learning Outcomes: After studying this paper the students will know –

- a. Chemistry of enzyme catalysis.
- b. Enzyme kinetics.
- c. Regulation of enzyme activity

References:

- a. Berg J.M., Tymoczko J.L. and Stryer L. (2006). Biochemistry: international edition: WH Freeman & Company Limited.
- b. Boyer R.F. (2006). Biochemistry Laboratory: Modern Theory and Techniques.
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- g. Thimmaiah S.K. (1999). Standard Methods for Biochemical Analysis. Kalyani publishers.
- h. Wilson K. and Walker J.M. (2000). Principles and techniques of practical biochemistry: Cambridge University Press.

Practical:

1. Enzymes: Salivary Amylase, Protease and Invertase from latex, Esterase from Pea and alkaline phosphatase from milk.
2. Specific activity, pH and temperature optimum, energy of activation, K_m and V_{max} . Ammonium sulphate fractionation of esterase from Pea.
3. Photo-oxidation of methylene blue.
Photosynthetic reduction of 2,6-dichlorophenolindophenols.

<p style="text-align: center;">M.Sc. Biochemistry III Semester</p>	<p style="text-align: center;">Practical 3A Experiments in Immunology, Metabolism of Amino acids, Proteins and Nucleic acids; Study Tour and tour report.)</p>	<p style="text-align: center;">HC – Hard Core</p>
<p>Total Hours: 64</p>	<p>Credits: 02(LTP - 0:0:4)</p>	<p>Total Marks: 15+15+70 = 100</p>

1. Estimation of proteins using Bradford's method.
2. Estimation of proteins using Bicinchoninic acid method.
3. Estimation of A/G ratio in blood.
4. Estimation of aminoacids using ninhydrin method.
5. Purification of IgG.
6. Slide agglutination test/ Blood grouping.
7. Immunoprecipitation test: Ochterlony double diffusion assay.
8. Estimation of Urea by DAMO method and Clinical significance.
9. Estimation of uric acid and Clinical significance.
10. Estimation of Creatinine and Clinical significance.
11. Photo-oxidation of methylene blue.
12. Photosynthetic reduction of 2,6 dichlorophenolindophenol.
13. Identification and assessment of leguminous root nodules for Rhizobium.
14. Oxygen generation during photosynthesis.
15. Estimation of glutathione.
16. Estimation of bilirubin.
17. Study tour and report.

M.Sc. Biochemistry III Semester	Practical 3B Experiments in Enzymology; Research Paper Presentaation	HC – Hard Core
Total Hours: 64	Credits: 02(LTP - 0:0:4)	Total Marks: 15+15+70 = 100

1. Estimation of activity of Salivary amylase.
2. Estimation of Specific activity of Salivary amylase.
3. Estimation of optimum pH for the activity of Salivary amylase.
4. Estimation of optimum buffer conjugates for activity of Salivary amylase.
5. Estimation of optimum buffer concentration for activity of Salivary amylase.
6. Estimation of temperature optimum for Salivary amylase.
7. Time kinetics of Salivary amylase.
8. Estimation of energy of activation of Salivary amylase.
9. Effect of enzyme concentration on activity of Salivary amylase.
10. Estimation of Km and Vmax of Salivary amylase.
11. Plotting Lineweaver-Burk plot for Salivary amylase.
12. Assessment of effects of selected metal ions and drugs on the activity of Salivary amylase.
13. Purification of Alkaline phosphatase from bovine milk by differential centrifugation.
14. Estimation of activity of Alkaline phosphatase.
15. Estimation of Specific activity of Alkaline phosphatase and fold purity.
16. Calculation of fold purity of Alkaline phosphatase.
17. Purification of Invertase from plant latex.
18. Estimation of activity of Invertase.
19. Estimation of Specific activity of Invertase.
20. Calculation of fold purity of Invertase.
21. Purification of Esterase from peas by using ammonium sulphate precipitation.
22. Estimation of activity of Esterase.
23. Estimation of Specific activity of Esterase and fold purity.
24. Calculation of fold purity of Esterase.
25. Purification of Proteases from plant latex.
26. Estimation of activity of Protease.
27. Estimation of Specific activity of Protease.
28. Calculation of fold purity of Protease.
29. Estimation of catalase activity and specific activity.
30. Assessment of clinically relevant enzymes: SGOT, SGPT, Creatine Kinase, Lactate Dehydrogenase.
31. Seminar

M.Sc. Biochemistry III Semester	Metabolism of Nucleic Acids	SC –Soft Core
Total Hours: 48	Credits: 03(LTP - 3:1:0)	Total Marks: 15+15+70 = 100

Learning Objectives: Students should study this paper to know –

- The basics of nucleic acid metabolism.
- To understand the nitrogen metabolism.
- Regulation of nucleic acid metabolism

Module	Course contents	
1	Purines and pyrimidines: Pathways of biosynthesis and degradation of nucleic acids, purines and pyrimidines, uric acid formation. Salvage pathways, de novo biosynthetic pathways and regulations.	12h
2	Gout and Lysch-Nyhan syndrome. Conversion of nucleotides to deoxynucleotides. Mechanisms of action of methotrexate, 5-fluorouridine, azathymidine. Biosynthesis of cofactors: NAD ⁺ , FAD and coenzyme A, polyamine biosynthesis and their metabolic role.	12h
3	Photosynthesis: Photosynthetic apparatus in plants, photosystems I and II, light harvesting antenna complex. Electron flow and phosphorylation; cyclic and noncyclic, oxygen evolution, Calvin cycle. C ₃ , C ₄ and CAM cycle. Photorespiration, bacterial photosynthesis. Regulation of photosynthesis. RUBISCO.	12h
4	Nitrogen metabolism: Importance of nitrogen in biological systems, nitrogen cycle. Nitrogen fixation; symbiotic and non-symbiotic, nitrogenase complex, energetics and regulation. Formation of root nodules in legumes. Assimilation of nitrate and ammonium ion.	12h

Learning Outcomes: After studying this paper the students will know –

- Chemistry of nucleic acid metabolism. .
- Importance of nucleic acid metabolism.
- Mechanism of photosynthesis and nitrogen metabolism.

References:

- Berg J.M., Tymoczko J.L. and Stryer L. (2006). Biochemistry: international edition: WH Freeman & Company Limited.
- Chatterjee C.C. (2017) Human physiology: Medical Allied Agency: CBS Publishers and Distributors Pvt. LTD.
- Devlin T.M. (2020). Textbook of biochemistry: with clinical correlations (8th Edition). New York: J. Wiley & Sons.
- Nelson D.L., Lehninger A.L. and Cox M.M. (2008). Principles of biochemistry: Macmillan.

e. Voet D. and Voet J.G. (2010). Biochemistry (4th Edition). New York: J. Wiley & Sons.

M.Sc. Biochemistry III Semester	Metabolism of Amino acids and Proteins	SC – Soft Core
Total Hours: 48	Credits: 03(LTP - 3:1:0)	Total Marks: 15+15+70 = 100

Learning Objectives: Students should study this paper to know –

- The basics of metabolism.
- Role of proteins and amino acid in metabolism.
- Interactions among the metabolic enzymes.

Module	Course contents	
1	Proteins: General mechanisms of degradation in cells; ubiquitin-proteasome pathway, lysosomal pathway. Degradation and biosynthesis of glycoproteins and proteoglycans. Degradation and Biosynthesis of heme and porphyrins.	12h
2	Non ribosomal peptide synthesis and Biosynthesis of physiologically active amines: glutathione, gramicidine. Biosynthesis of physiologically active amines; serotonin, histamine, dopamine, norepinephrine and epinephrine.	12h
3	Degradation and biosynthesis of individual amino acids: Aliphatic, aromatic, and branched chain amino acids. Role of cofactors; PLP and THF in amino acid metabolism. Deamination, transamination, decarboxylation desulphuration process. Differences in the pathways in microorganisms, plants and animals. Regulation of amino acid biosynthesis; transglutaminase cycle, urea cycle.	12h
4	Intermediary metabolism and In born errors of metabolism: Ketogenic and glucogenic amino acids. In born errors of amino acid degradation; Phenylketonuria, alkaptonuria, maple syrup urine. Role of Hormones in the regulation of protein and amino acid metabolism: HPA axis. Adrenal gland and pancreatic hormones	12h

Learning Outcomes: After studying this paper the students will know –

- Chemistry of protein and amino acid metabolism. .
- Importance of protein and amino acid metabolism.
- Role of hormones in the regulation of protein and amino acid metabolism.

References:

- Berg J.M., Tymoczko J.L. and Stryer L. (2006). Biochemistry: international edition: WH Freeman & Company Limited.
- Devlin T.M. (2020). Textbook of biochemistry: with clinical correlations (8th Edition). New York: J. Wiley & Sons.

- c. Nelson D.L., Lehninger A.L. and Cox M.M. (2008). Principles of biochemistry: Macmillan.
- d. Voet D. and Voet J.G. (2010). Biochemistry (4th Edition). New York: J. Wiley & Sons.

M.Sc. Biochemistry III Semester	Membrane Biology	SC –Soft Core
Total Hours: 48	Credits: 03(LTP - 3:1:0)	Total Marks: 15+15+70 = 100

Learning Objectives: Students should study this paper to know –

- The basics of membrane structure.
- Role of membranes in the biological system.
- Biological processes involving membranes.

Module	Course contents	
1	Biomembranes Physicochemical properties of biological membranes; compositions, supra molecular organization. Models of membrane; Gorter and Grendel's experiment, bilayer structure, Daniell - Davson model of membrane. Evolution in concept of membrane models, Singer and Nicholson's model. Newer models.	12h
2	Membrane asymmetry: lipids, proteins and carbohydrates and their lateral diffusion. Biogenesis of lipids and proteins, polarized cells, membrane domains; caveolae, rafts, membrane lipid and protein turnover, intracellular targeting of proteins. Biogenesis of sub cellular organelles.	12h
3	Methods of study of membrane structure: Lipid transfer proteins, phospholipases, chemical methods, amino-phospholipid translocation, TNBS reagent, freeze fracture and freeze etching. Lipid vesicles; liposome preparations and application, function of sterols in membranes. FRET, FRAP, single particle tracking, EM of membranes, calorimetry, confocal microscopy of membrane dynamics. Cell fusion, shedding of membrane. Physico-chemical properties of membranes: membrane lipid phases, bilayer phase, non-bilayer phase, phase transition, membrane potential, bilayer nature.	12h
4	Membrane transport: Laws of diffusion across membranes, simple diffusion, facilitated diffusion and active transport. Glucose transporters, Ca ²⁺ ATPase, Na ⁺ -K ⁺ ATPase (Structure and mechanism of action), bacterial phosphotransferase system. Endocytosis, receptor mediated endocytosis, exocytosis, ion channels; gated and non gated, aquaporin channel. Nerve transmission: Acetylcholine receptor and neurotransmitters, mechanisms of nerve conduction, resting and action potential, ion channels, ionophores, patch clamp technique. Presynaptic and postsynaptic membranes. nicotinic and muscarinic neurons. GABA, NMDA, structure and function. Muscle contraction: Mechanisms, role of calcium, calmodulin, phospholamban.	12h

Learning Outcomes: After studying this paper the students will know –

- Biological processes involving membranes.
- Importance of membranes in the biological system.

References:

- a. Berg J.M., Tymoczko J.L. and Stryer L. (2006). Biochemistry: international edition: WH Freeman & Company Limited.
- b. Devlin T.M. (2020). Textbook of biochemistry: with clinical correlations (8th Edition). New York: J. Wiley & Sons.
- c. Nelson D.L., Lehninger A.L. and Cox M.M. (2008). Principles of biochemistry: Macmillan.
- d. Voet D. and Voet J.G. Biochemistry (4th Edition). New York: J. Wiley & Sons. (2010).

M.Sc. Biochemistry IV Semester	Project Work	HC –Hard Core
Total Hours: 320	Credits: 10(LTP - 0:2:20)	Total Marks: 15+15+70 = 100

M.Sc. Biochemistry IV Semester	Clinical Biochemistry	SC – Soft Core
Total Hours: 48	Credits: 03(LTP - 3:1:0)	Total Marks: 15+15+70 = 100

Learning Objectives: Students should study this paper to know –

- The basics of clinical biochemistry.
- Clinical Diagnosis of different diseases.
- Different types of clinical diagnosis.

Module	Course contents	
1	Basic concepts: Health and disease. Normal and pathological changes, affecting cells in the body. Cell death and the physiological causes; physical, chemical, biological agents and nutritional deficiency. Blood:Composition, cells, functions of plasma proteins and lipo-proteins in diseases. Disorders of hemoglobin; thalassemia, sickle cell anemia. Anemias; microcytic, normocytic and macrocytic. Diagnostic enzymology:Clinically important enzymes; alkaline phosphatase, AST, ALT and isoenzymes of creatine kinase and LDH	12h
2	Endocrine system: Endocrine system: Overview of the physiology of endocrine system. Laboratory diagnosis to assess the function of pituitary, thyroid, adrenals and gonads. Disorders; graves disease, Hashimoto disease, Addison's disease, hypo and hyper secretion of hormones. Acromegaly, gigantism.	12h
3	Hepatobiliary, Kidney, and GI System: Hepatobiliary system: Overview of hepatobiliary system.Biochemical indices of hepatobiliary diseases. Diagnosis of liver function tests. Bile pigments - formation of bilirubin, urobilinogen, bile acids. Jaundice; prehepatic, hepatic and post hepatic. Diseases of the liver - Hepatitis cholestasis, cirrhosis, fatty liver and gallstones. Overview of renal system.Assessment of renal function; creatine clearance, renal calculi, uremia, laboratory investigation of kidney disorders. Gastrointestinal disorders:Fractional gastric analysis, hypo and hyper acidity, gastric ulcers, malabsorption syndrome, steatorrhea and diarrhoea.	12h
4	Cardiac, Skeletal Muscles and Nervous System: Overview of heart and skeletal muscles, CNS. Major Cardio vascular system, atherosclerosis, risk factors and pathogenesis. Diagnosis and prognosis. Assessment of CSF.	12h

Learning Outcomes: After studying this paper the students will know –

- Application of Biochemistry in the clinical diagnosis.
- Importance of biochemical parameters in the clinical diagnosis.

References:

- Berg J.M., J.L. and Stryer L. (2006). Biochemistry: international edition: WH Freeman & Company Limited.
- Chatterjee C.C. (2017). Human physiology: Medical Allied Agency: CBS Publishers and

Distributors Pvt. LTD.

- c. Devlin T.M. (2020). Textbook of biochemistry: with clinical correlations (8th Edition). New York: J. Wiley & Sons.
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- e. Murray R., Granner D., Mayes P. and Rodwell V. (2003). Harper's illustrated biochemistry (LANGE basic science): McGraw-Hill Medical.
- f. Nelson D.L., Lehninger A.L. and Cox M.M. (2008). Principles of biochemistry: Macmillan.
- g. Purohit S. and Mathur S. (1999). Drugs in Biotechnology fundamentals and applications. Maximillan publishers, India.
- h. Voet D. and Voet J.G. (2010). Biochemistry (4th Edition). New York: J. Wiley & Sons.

M.Sc. Biochemistry IV Semester	Biostatistics, Bioinformatics and Research Methodology	SC – Soft Core
Total Hours: 48	Credits: 03(LTP - 3:1:0)	Total Marks: 15+15+70 = 100

Learning Objectives: Students should study this paper to know –

- a. Knowledge of basic statistical methods to solve problems.
- b. Students are taught to operate various statistical software packages.
- c. The in-depth knowledge about the bioinformatics.
- d. The basics of research.
- e. To understand the application of bioinformatics and statistics in research.
- f. Regulation in research.

Module	Course contents	
1	Introduction to Biostatistics: Introduction: Population, sample, sampling techniques, random sample. Mean, median, mode, range, variance, coefficient of variation, frequency, standard deviation, standard error. Representation of statistical data line graph, histogram, bar diagram, pie chart, scatter diagram. Collection of data: Relevance of sample size. Sources, methods-questionnaires, records, archives. Validation and standardization of the methods, modification and experimental design.	12h
2	Statistical tests: Probability: Rules of probability, binomial distribution, normal distribution, area under the curve, Z value, choosing sample size, hypothesis testing, Student's t test. One way ANOVA, correlation and regression. Goodness of fit, test of independence. Non parametric statistics, sign test, rank sum test, rank correlation.	12h
3	Bioinformatics: Biological databases: Introduction, classification of biological databases, retrieval of biological database systems. Molecular Modeling Database at NCBI, Molecular visualization software (RASMOL). Phylogenetics Clustal. Prediction of genes (Gene finder, ORF finder). Sequence comparison and database search: Introduction, different types of alignment. Iterative refinement methods, pattern matching in DNA and protein sequences, PAM matrices, BLAST, FAST and FASTA. nucleotide sequence analysis, single nucleotide polymorphism, primer designing. Emboss, prosite, prodom, protein expression profiling. Prediction of Secondary structure of proteins, softwares for secondary structure prediction, protein families and classification, (trans membrane regions). CATH and SCOP. Introduction to drug designing: In silico analysis, physico-chemical property prediction, aqueous solubility, Lipinski's rule of five. Docking methods: Three dimensional descriptions of binding site environment and energy calculation, automatic docking method. Three dimensional database search approaches, protein-protein interactions, design of ligands, drug-receptor interactions, automated structure construction methods	12h

4	<p>Research Methodology: Definition – History of scientific research: Definition, Characteristics, types. Identification of the problem, assessing the status of the problem, formulating the objectives, preparing the design (experimental or otherwise), actual investigation. Literature Review, Hypothesis, Data– Categorical, nominal & Ordinal. Methods of Collecting Data: Observation, field investigations, direct studies, questionnaires: Types of Report – Technical Reports and Thesis – Significance – Different steps in the preparation – Layout, structure and Language of typical reports - Illustrations and tables. Bibliography: Citations and references; Plagiarism – Citation and Acknowledgement</p> <p>Ethical Issues – Ethical Committees, Types of experiments that require ethical clearance – Commercialization – copy right – royalty – Intellectual Property rights and patent law – Reproduction of published material – Plagiarism – Citation and Acknowledgement – Reproducibility and accountability.</p>	12h
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Learning Outcomes: After studying this paper the students will know

- a. Basics and ethics in research.
- b. Writing and analysis of research articles.
- c. Knowledge of basic statistical methods to solve problems.
- d. Students are taught to operate various statistical software packages.
- e. The in-depth knowledge about the bioinformatics.
- d. The importance of statistics in research and prepares them for a career in research
- f. The student will be able to apply statistics to basic principles of biology.
- g. Understanding about the sequence analysis tools and also about the drug discovery.

References:

- a. Bulakh P.M., Patki P.S. and Chodhary A.S. (2010). Research Methodology. Expert Trading Corporation Dahisar West, Mumbai.
- b. Garg B.L., Karadia R., Agarwal F. and Agarwal U.K. (2002). An introduction to Research Methodology. RBSA Publishers.
- c. Gupta S.P. (2008). Statistical Methods. (37th Edition). Sultan Chand and Sons. New Delhi.
- d. Kothari C.R.(2008). Research Methodology: Methods and Techniques. (2nd Edition). New Age International Publishers, New Delhi.
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- f. Sinha S.C. and Dhiman A.K. (2002). Research Methodology. Ess Ess Publications.
- g. Wadehra B.L. (2000). Law relating to patents, trade marks, copyright designs and geographical indications. Universal Law Publishing.
- h. Amdekar, S.J. 2014. Statistical Methods for Agricultural and Biological Sciences. Narosa Publishing House.
- i. Baxevamis, A.D. and Ouellette, F. B. E. 2004. Bioinformatic: A practical guide to the analysis of genes and proteins. John Wiley & Sons.
- j. [Chen](#), D. G., and [Zhao](#), Y. 2018. New Frontiers of Biostatistics and Bioinformatics. Springer.
- k. Emden, H.V. 2008. Statistics for Terrified Biologists. Blackwell Publishing Press.
- l. Higgins, D. and Taylor, W. 2000. Bioinformatics – Sequence, Structure and Data Banks. Oxford University Press.
- m. Hodgman, C., French, A. and Westhead, D. 2010. BIOS Instant Notes: Bioinformatics. Taylon & Francis.
- n. [MacKenzie](#), G., and [Defen Peng](#), D. 2014. Statistical Modelling in Biostatistics and

Bioinformatics: Selected Papers. Springer.

- o. McCleery, R.H., Watt, T.A., and Hart, T. 2007. Introduction to Statistics for Biology (3rd Applications: Genomics, Proteomics and Drug Discovery. PHI Press.
- p. Srinivas, V.R. 2005. Bioinformatics: A modern approach. Prentice Hall India Learning Pvt. Ltd.
 - a.
- q. Ed.). CRC Press.
- r. Rastogi, S. S., Mendivata, N., and Rastogi, P. 2013. Bioinformatics Methods and

Scheme of Question Paper for (50 marks)

To be calculated for 15 marks for C1 and C2

M.Sc. I SEMESTER EXAMINATION

BIOCHEMISTRY (CBCS SCHEME)

PAPER- Name of the Paper (Hard core)

TIME: 2 HOURS

MAX. MARKS: 50

I. Answer any FIVE of the following: [5X2=10]

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.

II. Answer any FOUR of the following: [4X5=20]

- 7.
- 8.
- 9.
- 10.
- 11.

III. Answer any TWO of the following: [2X10=20]

- 12.
- 13.
- 14.

Scheme of Question Paper for End Semester Examination (70 marks)

C3

M.Sc. I SEMESTER EXAMINATION

BIOCHEMISTRY (CBCS SCHEME)

PAPER- Name of the Paper (Hard core)

TIME: 3 HOURS

MAX. MARKS: 70

Instruction: Draw diagrams wherever necessary.

IV. Answer any ten of the following: [10X2=20]

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.
- 8.
- 9.
- 10.
- 11.
- 12.

V. Answer any four of the following: [4X5=20]

- 13.
- 14.
- 15.
- 16.
- 17.
- 18.

VI. Answer any three of the following: [3X10=30]

- 19.
- 20.
- 21.
- 22.
- 23.

Question Paper Pattern for Practical – End Semester Examination

C1 and C2
M.Sc. Biochemistry

Course/Paper:
Course/Paper Code:.....

Time: 2 Hours

Max Marks: 50

- | | |
|---|------|
| 1. Conducting an Experiment/Micro-preparation /Plant identification | 20m |
| 2. Critical comments /Identification/ Procedure Writing | 10 m |
| 3. Viva-voce examination | 10m |
| 4. Class Records/Submissions. | 10m |

Question Paper Pattern for Practical – End Semester Examination

C3
M.Sc. Biochemistry

Course/Paper:
Course/Paper Code:.....

Time: 4 Hours

Max Marks: 70

- | | |
|--|-----|
| 1. Conducting Experiment/Micro-preparation /Plant identification | 25m |
| 2. Minor experiment/ Demonstrations | 15m |
| 3. Critical comments /Identification/ Procedure Writing | 10m |
| 4. Viva-voce examination | 10m |
| 5. Class Records/Submissions. | 10m |
