M.Sc.,
BIO CHEMISTRY

SYLLABUS

FROM THE ACADEMIC YEAR
2023 - 2024

TAMILNADU STATE COUNCIL FOR HIGHER EDUCATION, CHENNAI – 600 005

Programme:	**M.Sc BIOCHEMISTRY**
Programme Code:	**LIFC**
Duration:	**2 years**
Programme Outcomes:	**PO1.**To make students understand the importance of biochemistry as a subject that deals with life processes, as well as the concepts, theories and experimental approaches followed in biochemistry, in order to pursue a research career, either in an industry or academic setting. **PO2.**To develop analytical and problem-solving skills **PO3**.To create an awareness among the students on the interconnection between the interdisciplinary areas of biochemistry. **PO4**.To give the necessary practical skills required for biochemical techniques and analysis. **PO5**.To develop a communication and writing skills in students. **PO6**.To develop leadership and teamwork skills **PO7**.To emphasize the importance of good academic and work ethics and their social implications. **PO8**.To emphasize the importance of continuous learning and to promote lifelong learning and career development. **PO9**.To teach students how to retrieve information from a variety of sources, including libraries, databases and the internet. **PO10.** To teach students to identify, design and execute a research problem, analyze and interpret data and learn time and resource management.
Programme Specific Outcomes:	**Programme Specific Outcomes (PSO)** **On successful completion of this course, students should be able to**: **PSO1.** Understand the principles and methods of various techniques in Biochemistry, Immunology, Microbiology, Enzyme kinetics and Molecular Cell Biology. Based on their understanding, the students may would be able to design and execute experiments during their final semester project, and further research programs. **PSO2.** Insight on the structure-function relationship of biomolecules, their synthesis and breakdown, the regulation of these pathways, and their importance in terms of clinical correlation. Students will also acquire knowledge of the principles of nutritional biochemistry and also understand diseases and their prevention. **PSO3**. To understand the concepts of cellular signal transduction pathways and the association of aberrant signal processes with various diseases. Acquire insight into the immune system and its responses, and use this knowledge in the processes of immunization, vaccine development, transplantation and organ rejection. **PSO4.** To visualize and appreciatethe central dogma of molecular biology, regulation of gene expression, molecular techniques used in rDNA technology, gene knock-out and knock-in techniques. **PSO5.** To create awareness in students about the importance ofgood laboratory practices and the importance of ethical and social responsibilities of a researcher. Teach them how to review literature and the art of designing and executing experiments independently and also work as a part of a team.

List of Courses:

Semester	Title of the Course	Core/Elective/ Soft Skill	Credits	Tutorial Hours
I	Basics of Biochemistry	Core I	5	7
	Biochemical and Molecular Biology Techniques	Core II	5	7
	Physiology and Cell Biology (To include Hormones)	Core III	4	6
	Microbiology & Immunology	Elective – I	3	3
	Soft Skill - Laboratory course on Biomolecules and Biochemical techniques	Soft Skill	3	5
			20	**30**
II	Enzymology	2.1. Core-IV	4	4
	Cellular Metabolism	2.2 Core-V	4	4
	Clinical Biochemistry	2.3 Core – VI	4	4
	Laboratory course on Clinical Biochemistry	2.4 Core – VII	4	8
	Elective - II:Energy and Drug Metabolism	2.5 Generic Elective - II:	3	3
	Elective – III – Nutrition Biochemistry	2.6 Elective - III	3	3
	NME - I / SEC -Fundamentals of medical laboratory technology	2.7 Skill Enhancement Course	**2**	4
			24	**30**
III	Industrial Microbiology	3.1. Core-VIII	4	4
	Molecular Biology	3.2. Core-IX	4	4
	Gene Editing, Cell and Gene therapy	3.3 Core-X	4	4
	Biostatistics and Data Science	3.4 Core – XI	4	4
	Laboratory course onEnzymology , Microbiology And Cell Biology	3.5 Core – XII	4	8
	Molecular basis of disease and therapeutic strategies	3.6 Discipline Centric Elective - IV	3	3
	*Internship [Clinical Laboratory]Industrial Visit – Biotech	3.7 NME II/ SEC- II		
		3.7 Internship/ Industrial Activity	2	3
			25	**30**

IV	Pharmaceutical Biochemistry	4.1. Core-XIII	5	6
	Biochemical Toxicology	4.2 Core-XIV	5	6
	Project and viva	4.3 Project with viva	7	10

		voce		
	Bio-safety, Lab Safety and IPR	4.4Elective - V (Industry / Entrepreneurship) 20% Theory 80% Practical	3	4
	Developmental Biology	4.5 Skill Enhancement course / Professional Competency Skill	2	4
	Industrial Visit – Pharma or Food Processing	4.6 Extension Activity	1	
			23	**30**
			92	

*****Internship will be carried out during the summer vacation of the first year and marks should be sent to the University by the College and the same will be included in the Third Semester Marks Statement.

M.SC., Biochemistry
Programme Structure

Sem	Paper Code	Courses	Title of the paper		Credits	Hours/ Week	Marks		
			I Semester				**I**	**E**	**Total**
I	23MBC1C1	Core 1	Basics of Biochemistry	T	5	7	25	75	100
	23MBC1C2	Core 2	Biochemical and molecular biology techniques	T	5	7	25	75	100
	23MBC1C3	Core 3	Physiology and cell biology	T	4	6	25	75	100
	23MBC1E1	DSE-1	Microbiology and Immunology	T	3	5	25	75	100
	23MBC1P1	Soft Skill	Soft Skill - Laboratory Course On Biomolecules And Biochemical Techniques	P	3	5	25	75	100
					20	**30**	**125**	**375**	**500**
			II Semester						
II	23MBC2C1	Core 4	Enzymology	T	4	4	25	75	100
	23MBC2C2	Core 5	Cellular Metabolism	T	4	4	25	75	100
	23MBC2C3	Core 6	Clinical biochemistry	T	4	4	25	75	100
	23MBC2P1	Core 7	Laboratory Course On Clinical Biochemistry	P	4	8	25	75	100
	23MBC2E1	DSE-2	Energy and drug metabolism	T	3	3	25	75	100
	23MBC2E2	DSE -3	Nutritional Biochemistry	T	3	3	25	75	100
	23MBC2S1	SEC-1	Fundamental of Medical Laboratory technology	T	2	4	25	75	100
					24	**30**	**175**	**525**	**700**
			III Semester						
III	23MBC3C1	Core 8	Industrial Microbiology	T	4	4	25	75	100
	23MBC3C2	Core 9	Molecular biology	T	4	4	25	75	100
	23MBC3C3	Core 10	Gene Editing Cell and Gene therapy	T	4	4	25	75	100
	23MBC3C4	Core 11	Biostatistics and Data Science	T	4	4	25	75	100
	23MBC3P1	Core 12	Laboratory Course On Enzymology, Microbiology and Cell Biology	P	4	8	25	75	100
	23MBC3E1	DSE-4	Molecular basis of diseases and therapeutic strategies	T	3	3	25	75	100
	23MBC3I	SEC-2	*Internship[Clinical Laboratory]Industrial Visit – Biotech		2	3	25	75	100
					25	**30**	**175**	**525**	**700**
			IV Semester						
IV	23MBC4C1	Core 13	Pharmaceutical Biochemistry	T	5	6	25	75	100
	23MBC4C2	Core 14	Biochemical Toxicology	T	5	6	25	75	100
	23MBC4PR		Project and viva		7	10	25	75	100
	23MBC4E1	DSE - 5	Bio-safety, Lab Safety and IPR	T	3	4	25	75	100
	23MBC4S1	SEC-3	Developmental Biology	T	2	4	25	75	100
	--		Extension Activity		1				
					23	**30**	**125**	**375**	**500**
			Total		**92+ EC**		**600**	**1800**	**2400**

Core Courses

DSE – Discipline Specific Elective –Give more option to the student(Choice) and it may be conducted by parallel sessions.

SEC- Skill Enhancement Course

Dissertation- Marks -Vivo-voce (50) + thesis (100) + internal (50) = 200

Internship report –Marks -Vivo-voce (25) + reports (50) + internal (25) = 100

***AEC- Ability Enhancement Courses (may be included by altering the surplus credits and hours of other courses)**

Course Code 23MBC1C1	COREPAPERI	
Title of the Course:	BASICS OF BIOCHEMISTRY	
Credits:	5	Hours-7
Pre-requisites, ifany:	BasicKnowledgeofBiochemistry and Biomolecules	
CourseObjectives	Themainobjectivesofthiscourseareto: 1. Students will be introduced to the structureofbiomolecules. 2. Thesignificanceofcarbohydratesinbiologicalprocesses will be understood. 3. The structure, properties and biological significance of lipids in the biological system will be studied 4. Students will learn about the concepts of protein structure and their significance in biological processes and creatively comprehendtheroleof membranecomponentswith theirbiologicalsignificance. 5. Students will gain knowledge about thestructuresandfunctionalrolesofnucleicacids in the biologicalsystem	
CourseOutcomes	On successful completionofthecourse,thestudentsshouldbeableto: **CO1 :**Explain the chemicalstructureandfunctionsof carbohydrates.(K1,K2) **CO2:**Usingtheknowledgeoflipidstructureandfunction, explain how it plays aroleinSignallingpathways (K3,K4) **CO3:** Describe the various levels of structural organisation of proteins andtheroleof proteinsinbiologicalsystem(K4,K5) **CO4:**Applytheknowledgeofproteinsincell-cellinteractions.(K3,K4) **CO5.**Applyingtheknowledgeofnucleicacidsequencinginresearchanddiagnosis(K2,K3,K4)	

Units I	Carbohydrates- Classification, structure (configurations and conformations, anomeric forms), function and properties of monosaccharides, mutarotation, Disaccharides and oligosaccharides with suitable examples . Polysaccharides - Homopolysaccharides (starch, glycogen, cellulose, inulin, dextrin, agar, pectin, dextran). Heteropolysaccharides - Glycosaminoglycans– source, structure, functions of hyaluronic acid, chondroitin sulphates, heparin, keratan sulphate,. Glycoproteins - proteoglycans. O- Linked and N-linked glycoproteins. Biological significance of glycan. Blood group polysaccharides. Bacterial cell wall (peptidoglycans, teichoic acid) and plant cell wall carbohydrates.
Unit II	Lipids – Classification of lipids, structure, properties and functions of fatty acids, triacylglycerols, phospholipids, glycolipids, sphingolipids and steroids – Biological importance. Eicosanoids- classification, structure and functions of prostaglandins, thromboxanes, leukotrienes. Lipoproteins – Classification ,structure, transport (endogenous and exogenous Pathway) and their biological significance.

Unit III	Overview of Aminoacids - classification, structure and properties of amino acids, Biological role.Non Protein aminoacids and their biological significance .Proteins – classification based on composition, structure and functions. Primary, secondary, super secondary (motifs) (Helix-turn –helix, helix-loop-helix, Beta-alpha-beta motif, Rosemann Rossmann fold , Greek key),tertiary and quaternary structure of proteins. Structural characteristics of collagen and hemoglobin. Determination of amino acid sequence.Chemical synthesis of a peptide, Forces involved in stabilization of protein structure. Ramachandran plot. Folding of proteins. Molecular chaperons – Hsp 70 and Hsp 90 - biological role.
Unit IV	Membrane Proteins - Types and their significance. Cytoskeleton proteins - actin , tubulin , intermediate filaments . Biological role of cytoskeletal proteins. Membrane structure-fluid mosaic model
Units V	Nucleic acids – types and forms (A, B, C and Z) of DNA. Watson-Crick model-Primary, secondary and tertiary structures of DNA. Triple helix and quadruplex DNA. Mitochondrial and chloroplast DNA. DNA supercoiling (calculation of Writhe, linking and twist number). Determination of nucleic acid sequences by Maxam Gilbert and Sanger's methods. Forces stabilizing nucleic acid structure. Properties of DNA and RNA. C-value, C-value paradox, Cot curve. Structure and role of nucleotides in cellular communications. Major and minor classes of RNA, their structure and biological functions
Reading List (PrintandOnline)	1. https://bio.libretexts.org/Bookshelves/Biochemistry/Book%3A_Biochemistry_Online_(Jakubowski) 2. https://www.thermofisher.com/in/en/home/life-science/protein-biology/protein-biology-learning-center/protein-biology-resource-library/pierce-protein-methods/protein-glycosylation.html 3. https://ocw.mit.edu/courses/biology/7-88j-protein-folding-and- human-disease-spring-2015/study-materials/ 4. https://www.open.edu/openlearn/science-maths-technology/science/biology/nucleic-acids-and-chromatin/content-section-3.4.2 5. https://www.genome.gov/genetics-glossary/Cell-Membrane https://nptel.ac.in/content/storage2/courses/102103012/pdf/mod3.pdf
Self-Study	1. Classification of Sugars 2. Nutritional classifcation of fatty acids
Recommended Texts	1. DavidL.NelsonandMichaelM.Cox(2012)LehningerPrinciplesofBiochemistry(6thed)W.H.Freeman. 2. Voet.D&Voet.J.G(2010)Biochemistry,(4thed),JohnWiley&Sons,Inc. 3. Metzler D.E(2003).Thechemicalreactionsoflivingcells(2nded),Academic Press. 4. ZubayG.L(1999)Biochemistry,(4thed),McGrew-Hill. 5. Lubert Stryer(2010)Biochemistry,(7thed),W.H.Freeman 6. Satyanarayan,U(2014)Biochemistry(4thed), ArunabhaSenBooks &Allied(P)Ltd,Kolkata.

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total
10	10	5	75	100

Recall(K1)-Simpledefinitions,MCQ,Recallsteps,Conceptdefinitions.

Understand/Comprehend(K2)-MCQ,True/False,Shortessays,Concept explanations,shortsummaryoroverview.

Application(K3)-Suggestidea/conceptwithexamples,Solveproblems,Observe,Explain.

Analyse(K4) – Problem-saving questions,Finish a procedure in many steps,Differentiate between various ideas.

Evaluate(K5)-Longer essay/ Evaluationessay,Critiqueorjustifywithprosandcons

Create (K6) – Check knowledge in specific or offbeat situations.Discussion.

Mapping with Programme Outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO1	S	L	M	S	M	M	M	S	M	M
CO2	S	M	L	S	M	M	M	S	M	M
CO3	S	M	M	S	S	M	L	S	M	M
CO4	S	M	M	S	M	M	M	S	M	M
CO5	S	S	M	S	S	M	M	S	M	M

Strong:S- Strong; Medium: M-Medium; LowL-Low

Course Code 23MBC1C2	COREPAPERII	
Title of the Course:	BIOCHEMICAL AND MOLECULAR BIOLOGY TECHNIQUES	
Credits:	5	Hours:7
Pre-requisites, if any:	Comprehensive Knowledge of Tools of Biochemistry/Molecular Biology	
Course Objectives	Biochemical techniques combine various inter-disciplinary methods in biological research and the course aims to provide students with the following objectives: 1. To understand the various techniques used in biochemical investigation and microscopy. 2. To explain chromatographic techniques.\ and their applications 3. To explain electrophoretic techniques. 4. To comprehend the spectroscopic techniques and demonstrate their applications in biochemical investigations. 5. To acquire knowledge of radio labelling techniques and centrifugation.	
Course Outcomes	After completion of the course, the students should be able to: **CO1.** Attain good knowledge in modern used in biochemical investigation and microscopy and apply the experimental protocols to plan and carry out simple investigations in biological research. (K1, K5) **CO2.**Demonstrate knowledge to implement the theoretical basis of chromatography in upcoming practical course work.(K3, K5) **CO3.** Demonstrate knowledge to implement the theoretical basis of electrophoretic techniques in research work.(K3, K5) **CO4.**Tackle more advanced and specialized spectroscopic techniques that are pertinent to research.(K1, K2 & K5) **CO5.**Tackle more advanced and specialized radioisotope and centrifugation techniques that are pertinent to research work.(K1, K2 & K5)	
Units		
UnitI	General approaches to biochemical investigation, cell culture techniques and microscopic techniques. Organ and tissue slice technique, cell distribution and homogenization techniques, cell sorting, and cell counting, tissue Culture techniques. Cryopreservation, Biosensors- principle and applications. Principle, working and applications of light microscope, dark field, phase contrast and fluorescent microscope. Electron microscope- Principle, instrumentation of TEM and SEM, Specimen preparation and applications-shadow casting, negative staining and freeze fracturing.	
Unit II	Chromatographic Techniques: Basic principles of chromatography- adsorption and partition techniques. Chiral Chromatography and counter current Chromatography. Adsorption Chromatography – Hydroxy apatite chromatography and hydrophobic interaction Chromatography. Affinity chromatography.Gas liquid chromatography- principle, instrumentation, column development, detectors and applications. Low pressure column chromatography – principle, instrumentation, column packing, detection, quantitation and column efficiency, High pressure liquid chromatography- principle, instrumentation, delivery pump, sample injection unit, column packing, development, detection and application. Reverse HPLC, capillary electro chromatography and perfusion chromatography.	

Unit III	Electrophoretic Techniques: General principles of electrophoresis, supporting medium, factors affecting electrophoresis, Isoelectric focusing-principle, ampholyte, development of pH gradient and application. PAGE-gel casting-horizontal, vertical, slab gels, sample application, detection-staining using CBB, silver, fluorescent stains. SDS PAGE-principle and application in molecular weight determination principle of disc gel electrophoresis ,2D PAGE. Electrophoresis of nucleic acids-agarose gel electrophoresis of DNA, pulsed field gel electrophoresis- principle, apparatus, application. Electrophoresis of RNA, curve. Microchip electrophoresis and 2D electrophoresis, Capillary electrophoresis.
Unit IV	Spectroscopic techniques: Basic laws of light absorption- principle, instrumentation and applications of UV-Visible, IR, ESR, NMR, Mass spectroscopy, Turbidimetry and Nephelometry. Luminometry (Luciferase system, chemiluminescence). X - ray diffraction. Atomic absorption spectroscopy - principle and applications - Determination of trace elements
Unit V	Radiolabeling Techniques and Centrifugation: Nature of radioactivity-detection and measurement of radioactivity, methods based upon ionisation (GM counter) and excitation (scintillation counter), autoradiography and applications of radioactive isotopes, Biological hazards of radiation and safety measures in handling radioactive isotopes. Basic principles of Centrifugation. Preparative ultracentrifugation - Differential centrifugation, Density gradient centrifugation. Analytical ultracentrifugation - Molecular weight determination.
Reading List (Print and Online)	Principles and techniques of biochemistry and molecular biology: https://www.kau.edu.sa/Files/0017514/Subjects/principals%20and%20techinique s%20of%20biochemistry%20and%20molecular%20biology%207th%20ed%
Self-Study	1. Types of rotors 2. Colorimetry – principle and applications
Recommended Texts	1.Keith Wilson , John Walker (2010) Principles and Techniques ofBiochemistry and Molecular Biology (7th ed) Cambridge University Press 2.David Sheehan (2009), Physical Biochemistry: Principles andApplications (2nd ed), Wiley-Blackwell 3.David M. Freifelder (1982) Physical Biochemistry: Applications to Biochemistry and Molecular Biology,W.H.Freeman 4.Rodney F.Boyer (2012), Biochemistry Laboratory: Modern Theory and techniques,(2nd ed),Prentice Hall 5.Kaloch Rajan (2011), Analytical techniques in Biochemistry and Molecular Biology, Springer 6. Segel I.H (1976) Biochemical Calculations (2nd ed),John Wiley and Sons 7. Robyt JF (2015) Biochemical techniques: Theory and Practice (1st ed), CBS Publishers & Distributors

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

Methods of assessment:

Recall (K1) - Simple definitions, MCQ, Recall steps, Concept definitions.

Understand/ Comprehend (K2) - MCQ, True/False, Short essays, Concept explanations, short summary or overview.

Application (K3) - Suggest idea/concept with examples, Solve problems, Observe, Explain.
Analyse(K4) – Problem-saving questions, Finish a procedure in many steps, Differentiate between various ideas.
Evaluate (K5) - Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6) – Check knowledge in specific or offbeat situations. Discussion.
Mapping with Programme Outcomes:

S-Strong M-Medium L-Low	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S	L	M	S	S	L	L	S	S	M
CO 2	S	M	M	S	M	L	M	S	S	L
CO 3	S	M	L	S	M	M	M	S	M	L
CO 4	S	S	L	S	S	M	M	S	M	M
CO 5	S	S	M	S	M	M	M	S	M	M

Course code 23MBC1C3	CORE PAPER -III	
Title of the Course:	PHYSIOLOGY AND CELL BIOLOGY	
Credits:	4	Hours:6
Pre-requisites, if any:	Anatomy, Cells and Biological Compounds	
Course Objectives	To understand the functions and activities of organs, tissues or cells and of physical and chemical phenomena involved in the human body	
Course Outcomes	After completion of the course, the students should be able to: **CO1.** specifically understand the biological and chemical processes within a human cell (K1, K2, K5, K6) **CO2.** identify and prevent diseases(K2, K3,K4, k5, K6) **CO3.** understand defects in digestion, nutritional deficiencies and intolerances, and gastrointestinal pathologies(K1, K2, K3,K4, K5, K6) **CO4.** identify general characteristics in individuals with imbalances of acid- base, fluid and electrolytes.(K1 , K2 , K3 ,K4, K5, K6) **CO5.** process the mechanism: the transmission of biochemical information between cell membrane and nucleus. (K1, K2, K5)	
Units		
Unit I	Major classes of cell junctions- anchoring, tight and gap junctions. Major families of cell adhesion molecules (CAMs)- cadherins, integrins. Types of tissues. Epithelium- organisation and types. The basement membrane. Cell cycle- mitosis and meiosis, Cell cycle-phases and regulation. Cell death mechanisms- an overview-apoptosis, necrosis.	
Unit II	Reproductive system- sexual differentiation and development; sperm transport, sperm capacitation, semen analyses and Acrosome reaction. Clinical relevance of female reproductive physiology- menstrual cycle, pregnancy and menopause. Fertilisation and infertility issues.	
Unit III	Digestive system- structure and functions of different components of digestive system, digestion and absorption of carbohydrates, lipids and proteins, role of bile salts in digestion and absorption, mechanism of HCl formation in stomach, role of various enzymes and hormones involved in digestive system. Composition of blood, lymph and CSF. Blood cells - WBC, RBC and energy metabolism of RBC, Blood clotting mechanism and blood groups- ABO and Rhesus system.	
Unit IV	Respiratory system-Gaseous transport and acid-base homeostasis. Mechanism of the movement of O2 and CO2 through lungs, arterial and venous circulation. Bohr effect, oxygen and carbon dioxide binding haemoglobin. pH maintenance by cellular and intracellular proteins. Phosphate and bicarbonate buffers, Metabolic acidosis and alkalosis. Respiratory acidosis and alkalosis. Regulation of fluid and electrolyte balance.	
Unit V	Sensory transduction, Nerve impulse transmission- nerve cells, synapses, reflex arc structure, resting membrane potential, Nernst equation, action potential, voltage gated ion-channels, impulse transmission, neurotransmission, neurotransmitter receptors, synaptosomes, synaptotagmin, rod and cone cells in the retina, changes in the visual cycle, photochemical reaction and regulation of rhodopsin, odour	

	receptors, learning and memory. Chemistry of muscle contraction – actin and myosin filaments, theories involved in muscle contraction, mechanism of muscle contraction, energy sources for muscle contraction.
Unit VI	Hormones – Classification, Biosynthesis, circulation in blood, modification and degradation. Mechanism of hormone action, Target cell concept. Hormones of Hypothalamus, pituitary, Pancreatic, thyroid & parathyroid, adrenal and gonadal hormones. Synthesis, secretion, physiological actions and feedback regulation of synthesis.
Reading List (Print and online)	https://www.genome.gov/genetics-glossary/Cell-Cycle https://my.clevelandclinic.org/health/diseases/16083-infertility-causes https://www.webmd.com/heartburn-gerd/reflux-disease https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5760509/ https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3249628/
Self-Study	1. Variation in cell differentiation and progression 2. Lesch Nyhan syndrome ,orotic aciduria and GERD
Recommended Texts	1. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments (6th ed). John Wiley & Sons. Inc. 2. Bruce Alberts and Dennis Bray (2013),Essential Cell Biology,(4th ed),Garland Science. 3. De Robertis, E.D.P. and De Robertis, E.M.F. (2010). Cell and Molecular Biology.(8th ed). Lippincott Williams and Wilkins, Philadelphia. 4. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. (5th ed). Sunderland, Mass. Sinauer Associates, Inc. 5. Wayne M. Baker (2008) the World of the Cell. (7th ed). Pearson Benjamin Cummings Publishing, San Francisco. Cell Biology 6. John E. Hall (2010). Guyton and Hall Textbook of Medical Physiology (12th ed), Saunders 7. Harrison's Endocrinology by J. Larry Jameson Series: Harrison's Specialty, 19th Edition Publisher: McGraw-Hill, Year: 2016.

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

Methods of assessment:

Recall (K1) - Simple definitions, MCQ, Recall steps, Concept definitions.

Understand/ Comprehend (K2) - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.

Application (K3) - Suggest idea/concept with examples, Solve problems, Observe, Explain.

Analyse (K4) -Problem-saving questions, Finish a procedure in many steps, Differentiate between various ideas.

Evaluate (K5) - Longer essay/ Evaluation essay, Critique or justify with pros and cons.

Create (K6)- Check knowledge in specific or offbeat situations. Discussion

Mapping with Programme Outcomes:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	**S**	**S**	**S**	**S**	**S**	**M**	**S**	**S**	**S**	**M**

CO 2	**S**	**S**	**S**	**S**	**S**	**L**	**S**	**S**	**S**	**M**
CO 3	**S**	**S**	**S**	**S**	**S**	**M**	**M**	**S**	**S**	**M**
CO 4	**S**	**S**	**S**	**S**	**S**	**M**	**M**	**S**	**S**	**M**
CO 5	**M**	**S**	**L**	**S**	**S**	**L**	**M**	**M**	**L**	**L**

S-Strong M-Medium L-Low

Course code 23MBC1E1	CORE ELECTIVE PAPER -I	
Title of the Course:	MICROBIOLOGY & IMMUNOLOGY	
Credits:	3	Hours:5
Pre-requisites, if any:	The student should possess basic knowledge about microorganisms, types and their general characteristics. The students are also expected to possess basic understanding about the process of infection, immunological defence and pathological outcomes, if any.	
Course Objectives	To appreciate the classification of microorganisms based on their structure, size and shape with an insight into the ancient scriptures aboutmicrobes. To understand the role of microorganisms in environment and also to learn the cultureconditions. To recognize the possible contamination of foods by microorganisms, to learn about counteracting preservative measures and to know about probiotic nature ofmicroorganisms. To gain knowledge on pathogenic mediation by microorganisms and preventive measures as well. To comprehend the features of antimicrobial agents, their mechanism of action along with the side effects and also toexplore natural remedial measures againstmicrobes. Tobeabletoexploitthevariousfeaturesofmicroorganismsforthe beneficial industrialproduction.	
Course Outcomes	After completion of the course, the students should be able to: **CO1.** To classify (by both ancient and modern modes) different types of microorganismsandexplainlifecycleofthemicrobes(K1,K2&K5) **CO2.** To recognize the microorganisms involved in decay of foods and willbeabletoapplyvariouscounteractingmeasures.Thestudentsalso will be able to relate the role of certain beneficial microbes in day-to-day's food consumption. (K1, K2 &K4) **CO3.** To understand the common pathogenic bacterial and fungi that cause toxic effects and also will be able to employ curative measures. (K1 & K2) **CO4.**To analysevariousfeaturesofwidevarietyofantimicrobialagents along with their mode of action, in addition, being able to apprehend the valuable potentials of traditional and easily available herbs. (K2,K5 & K6) **CO5.**To applyknowledgegainedinproductionofindustriallyimportant products as both pharmaceutical and nutraceutical. (K2, K4 &K5)	
Units		
Unit I	Taxonomical classification - bacteria, viruses (DNA, RNA), algae, fungi and protozoa. Distribution and role of microorganisms in soil, water and air. Charaka's classification of microbes, lytic cycle and lysogeny. Types of culture media, isolation of pure culture, growth curve and the measurement of microbial growth.	

Unit II	Contamination and spoilage of foods – cereals, cereal products, fruits, vegetables, meat, fish, poultry, eggs, milk and milk products. General principles of traditional and modern methods of food preservation - Removal or inactivation of microorganisms, boiling, steaming, curing, pasteurization, cold processing, freeze drying, irradiation, vacuum packing, control of oxygen and enzymes. Microbes involved in preparation of fermented foods - cheese, yoghurt, curd, pickles, rice pan cake, appam, ragi porridge (கேழ்வரகுகூழ்)and bread.
Unit III	Food poisoning- bacterial food poisoning, *Salmonella*, *Clostridium blotulinum*(botulism), *Staphylococcus aureus*, fungal food poisoning – aflatoxin, food infection – *Clostridium, Staphylococcus* and *Salmonella*. Pathogenic microorganisms, *E. coli, Pseudomonas, Klebsilla, Streptococcus, Haemophilus, & Mycobacterium*, causes, control,prevention,cureandsafety.Foodmicrobiologicalscreening-Real time PCR, ELISA, Aerobic and anaerobic Plate Count, dye reduction method, anaerobic lactic acid bacteria, anaerobic sporeformers, Hazard analysis critical control point(HACCP)
Unit IV	Antimicrobial chemotherapy, General characteristics of antimicrobial agents. Mechanism of action – sulfonamides, sulphones and PAS.Penicillin,streptomycin-spectraofactivity,modeofadministration,mode of action, adverse effects and sensitivity test., Antiviral and antiretroviral agents, Antiviral RNA interference, natural intervention (Natural immunomodulators routinely usedin Indian medicalphilosophy).
Unit V	Immune system- definition and properties. Cells of the immune system – neutrophils, eosinophils, basophils, mast cells, monocytes, macrophages, dendritic cells, natural killer cells, and lymphocytes (B cells and T cells). Lymphoid organs- Primary and Secondary; structure and functions.Antigens and Complement System: definition, properties- antigenicity and immunogenicity, antigenic determinants and haptens.Antigen - antibody interactions - molecular mechanism of binding. Affinity, avidity, valency, cross reactivity and multivalent binding.Immunoglobulins & Immune Response: Structure, classes and distribution of antibodies. Antibody diversity.Immune system in health & disease, Transplantation immunology-graft rejection and HLA antigens.Immunological techniques, Flow cytometry and its application.
Reading List (Print and Online)	https://www.ijam.co.in/index.php/ijam/article/view/1326 (Krumi (Microorganisms) in Ayurveda- a critical review) Virtual Lectures in Microbiology and Immunology, University of Rochester https://www.frontiersin.org/articles/10.3389/fphar.2020.578970/full#h9 https://www.frontiersin.org/articles/10.3389/fmicb.2018.02151/full https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7559905/
Self-Study	1. Microbial infections and gut microbiome with relevance to *tridoshas* 2. Microbial population and pH variations in different dairy products.
Recommended Texts	1.Michael J.Pelczar Jr.(2001) Microbiology (5th ed), McGraw Hill Education (India) Private Limited 2.Frazier WC , Westhoff DC, Vanitha NM (2010) Food Microbiology (5th ed), McGraw Hill Education (India) Private Limited

	3. Willey J and Sherwood L (2011) ,Prescott's Microbiology (8th ed) McGraw Hill Education (India) 4. Ananthanarayanan ,Paniker and Arti Kapil (2013) Textbook of Microbiology (9th ed) OrientBlackSwan 5. Judy Owen , Jenni Punt Kuby (2013) ,Immunology (Kindt, Kuby Immunology) (7th ed) W. H. Freeman & Co 6. Brooks GF and Carroll KC (2013) JawetzMelnick&Adelbergs Medical Microbiology,(26th ed) McGraw HillEducation 7. Greenwood D (2012) ,Medical Microbiology, ElsevierHealth

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

Methods of assessment:
Recall (K1) - Simple definitions, MCQ, Recall steps, Concept definitions.
Understand/ Comprehend (K2) - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.
Application (K3) - Suggest idea/concept with examples, Observe, Explain.
Analyse (K4)- Finish procedure in stepwise manner, Differentiation between various ideas, Map knowledge
Evaluate (K5) - Longer essay/ Evaluation essay, Critique or justify with pros and cons.
Create (K6)- Check knowledge in specific or offbeat situations, Discussion, Debating, Presentation
Mapping with Programme Outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	**S**	**L**	**S**	**S**	**S**	**S**	**M**	**S**	**S**	**S**
CO 2	**S**	**S**	**S**	**S**	**S**	**M**	**L**	**M**	**S**	**S**
CO 3	**S**	**M**	**M**	**S**	**M**	**M**	**M**	**M**	**L**	**M**
CO 4	**S**	**M**	**M**	**M**	**M**	**M**	**M**	**S**	**S**	**S**
CO 5	**S**	**L**	**S**	**S**	**M**	**L**	**L**	**S**	**S**	**S**

S-Strong M-Medium L-Low

Course code 23MBC1P1	SOFT SKILL	
Title of the Course:	LABORATORY COURSE ON BIOMOLECULES AND BIOCHEMICAL TECHNIQUES	
Credits:	3	Hours:5
Pre-requisites	Knowledge on basic principles, Instrumentation of Biochemical techniques and metabolic reactions	
Course Objectives	1. To instill skill in students enabling them to apprehend the wider knowledge about principles and techniques to be employed for the biomolecules under investigation. 2. 2.To inculcate the knowledge of various isolation and purification techniques of macromolecules like DNA, RNA, Glycogen and Starch, 3. To perform colorimetric estimations to quantify important metabolites like lactate and tryptophan and minerals like calcium and iron from various sources. 4. To achieve training in subcellular fractionation and to identify them by markers. 5. 5 To achieve training in various chromatographic techniques. 6. To perform the isolation and identification of the organelles of a cell using differential centrifugation. 7. To perform phytochemical screening and quantification enabling them to give an insight on phytochemicals this will be useful for future research.	
Course Outcomes	On successful completion of this course, students should be able to: **CO1.**The student will be able to acquire knowledge and skill in the techniques used in the isolation, purification and estimation of different biomolecules that are widely employed in research (K1, K2, K4) **CO2.**The students will get acquainted with Principle, Instrumentation and method of Performing UV absorption studies of DNA, Protein and interpreting the alteration occurred during the process of denaturation (K1,K2, K 3, K4). **CO3.**The student will be fine-tune in handling the instruments like colorimeter, spectrophotometer and will be able to estimate the biomolecules and minerals from the given samples (K1,K2,K4,) **CO4.** The student, in addition to acquiring skill in performing various biochemical techniques can also learn to detect presence of phytochemicals and quantify them in the plant sample.(K1,K2,K3,K4 & K6) **CO5.**The students will develop skill in analytical techniques like subcellular fractionation, Paper, Column and Thin layer Chromatography and the group experiments will enable them to build learning skills like team work, Problem solving, Communication ability. (K1, K2,K3,K4 & K6)	
Units		
Unit I	Biochemical studies and estimation of macromolecules 1. Isolation and estimation of glycogen from liver. 2. Isolation and estimation of DNA from animal tissue. 3. Isolation and estimation of RNA from yeast. 4. Purification of Polysaccharides –Starch and assessment of its purity	

Unit II	UV absorption 1. Denaturation of DNA and absorption studies at 260nm. 2. Denaturation of Protein and absorption studies at 280nm.
Unit III	Colorimetric estimations 1. Estimation of Pyruvate 2. Estimation of tryptophan.
Unit IV	Estimation of minerals 1. Estimation of calcium 2. Estimation of iron
Unit V	Plant Biochemistry 1.Qualitative analysis Phytochemical screening 2.Estimation of Flavonoids -Quantitative analysis
Unit VI	Group Experiments 1.Fractionation of sub-cellular organelles by differential centrifugation-Mitochondria and nucleus 2. Identification of the separated sub-cellular fractions using marker enzymes (any one) 3.Separation of identification of lipids by thin layer chromatography.. 4.Separation of plant pigments from leaves by columnchromatography 5.Identification of Sugars by Paper Chromatography 6.Identification of Amino acids by Paper Chromatography
Reading List (Print and Online)	1.https://www.researchgate.net/publication/313745155_Practical_Biochemistry_A_Student_Companion 2.https://doi.org/10.1186/s13020-018-0177-x 3.https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5368116/ 4.https://www.life.illinois.edu/biochem/455/Lab%20exercises/2Photometry/spectrophotometry.pdf 5.https://ijpsr.com/bft-article/determination-of-total-flavonoid-and-phenol-content-in-mimusops-elengi-linn/?view=fulltext 6.https://skyfox.co/wp-content/uploads/2020/12/Practical-Manual-of-Biochemistry.pdf
Self-Study	1. Laboratory Safety Rules, Requirements and Regulations. 2.Preparation of standard solutions and reagent
Books Recommended	1. David Plummer (2001) An Introduction to Practical Biochemistry (3rd ed) McGraw Hill Education (India) Private Ltd 2. Jayaraman, J (2011),laboratory Manual in Biochemistry, New age publishers 3. Varley H (2006) Practical Clinical Biochemistry (6th ed) , CBS Publishers 4. O. Debiyi and F. A. Sofowora, (1978)"Phytochemical screening of medical plants," Iloyidia, vol. 3, pp. 234–246, 5. Prof. Sarin A. Chavhan, Prof. Sushilkumar A. Shinde (2019) A Guide to Chromatography Techniques Edition:1 6. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan. Springer(2011)

Method of Evaluation:

Test I	Test II	End Semester Examination	Total	Grade
20	20	40	100	

Methods of assessment:

Recall (K1) - Simple definitions, MCQ, Recall steps, Concept definitions.

Understand/ Comprehend (K2) - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.

Application (K3) - Suggest idea/concept with examples, Solve problems, Observe, Explain.

Analyse (K4)- Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas

Evaluate (K5) - Longer essay/ Evaluation essay, Critique or justify with pros and cons.

Create (K6)- Check knowledge in specific or offbeat situations, Discussion.

Mapping with Programme Outcomes:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	S	S	S	S	M	S	L	S	M	S
CO 2	S	S	S	S	M	S	L	S	M	S
CO 3	S	S	S	S	M	S	M	S	M	S
CO 4	S	S	S	S	S	S	S	S	S	S
CO 5	S	S	S	S	S	S	S	S	S	S

S-Strong M-Medium L-Low

SEMESTER-II

Course code 23MBC2C1	**CORE PAPER IV**	
Title of the Course:	**ENZYMOLOGY**	
Credits:	**4**	**Hours:4**
Pre-requisites	Basic knowledge about catalysis, kinetics and chemical reaction mechanisms.	
Course Objectives	1.Students will be introduced to the theory and practice of enzymology. 2. Mechanisms of catalysis and factors affecting catalysis will be understood 3. The kinetics of enzyme catalyzed reactions in the absence and presence of inhibitors will be studied and the options for applying enzymes and their inhibitors in medicine will be analyzed. 4. Students will learn about the applications of enzymes in research, medicine, and industry, which will prepare them for careers in industrial and biomedical research. 5. The control of metabolic pathways and cellular responses through enzyme regulation will be emphasized.	
Course Outcomes	**On successful completion of this course, students should be able to:** **CO1:** Describe the catalytic mechanisms employed by enzymes (K1, K2 & K5) **CO2:** Choose and use the appropriate methods to isolate and purify enzymes and check the purity of the enzyme .(K1,K2 , K3,K4 & K5) **CO3:** Analyze enzyme kinetic data graphically, calculate kinetic parameters, determine the mechanism of inhibition by a drug/chemical and analyze options for applying enzymes and their inhibitors in medicine (K1, K2, K3 &K4) **CO4:** Explain allosterism and cooperativity and differentiate Michaelis-Menten kinetics from sigmoidal kinetics. The role played by enzymes in the regulation of vital cellular processes will be appreciated. (K1, K2 , K5, K6) **CO5:** Highlight the use of enzymes in industries and biomedicine (K1,K2& K3)	

Units	
Unit I	Introduction to enzymes and features of catalysis: A short history of the discovery of enzymes and how they became powerful biochemical tools. Holoenzyme, apoenzyme, cofactors, coenzyme, prosthetic groups, Classification and Nomenclature, Specificity of enzyme action-group specificity, absolute specificity, substrate specificity, stereochemical specificity. Active site, Identification of amino acids at the active site-trapping of ES complex, identification using chemical modification of amino acid side chains and by site-directed mutagenesis. Mechanisms of enzyme catalysis: acid-base catalysis, covalent catalysis, electrostatic

	catalysis, metal ion catalysis, proximity and orientation effects, Low barrier H-bonds, Structural flexibility Mechanism of action of chymotrypsin
Unit II	Enzyme techniques: Isolation and purification of enzymes - Importance of enzyme purification, methods of purification- choice of source , extraction, fractionation methods-based on size or mass (centrifugation, gel filtration); based on polarity (ion-exchange chromatography, electrophoresis, isoelectric focusing, hydrophobic interaction chromatography); based on solubility (change in pH, change in ionic strength); based on specific binding sites (affinity chromatography) ,choice of methods, Criteria of purity of enzymes. Enzyme units - Katal, IU. Measurement of enzyme activity - discontinuous, continuous, coupled assays; stopped flow method and its applications. Isoenzymes and their separation by electrophoresis with special reference to LDH
Unit III	Enzyme kinetics I: Thermodynamics of enzyme action, Activation energy, transition-state theory, steady-state kinetics & pre-steady-state kinetics.Single substrate enzyme catalyzed reactions -assumptions, Michaelis-Menten and Briggs-Haldane kinetics, derivation of Michaelis-Menten equation . Double reciprocal (Lineweaver-Burk) and single reciprocal (Eadie -Hofstee) linear plots, their advantages and limitations. Analysis of kinetic data- determination of Km, Vmax, kcat, and their physiological significance, Importance of kcat/Km. Enzyme inhibition: Irreversible inhibition. Reversible inhibition-Competitive, uncompetitive ,noncompetitive, mixed and substrate inhibition. Demonstration :Using Microsoft Excel to Plot and Analyze Kinetic Data
Unit IV	Enzyme kinetics II: Allosteric enzymes: Cooperativity, MWC and KNF models of allosteric enzymes, Sigmoidal kinetics taking ATCase as an example. Feedback inhibition-sequential, concerted, cumulative, enzyme-multiplicity with examples. Bi - Substrate reactions: Single Displacement reactions (SDR) (Ordered and Random bi bi mechanisms), Double Displacement reactions (DDR) (Ping pong mechanism), Examples, Cleland's representation of bisubstrate reactions, Graphical analysis (diagnostic plots) to differentiate SDR from DDR.
Unit V	Enzyme technology: Immobilization of enzymes – methods - Reversible immobilization (Adsorption, Affinity binding), Irreversible immobilization (Covalent coupling, Entrapment and Microencapsulation, Crosslinking, Advantages and Disadvantages of each method, Properties of immobilized enzymes,. Designer enzymes- ribozymes and deoxyribozymes, abzymes, synzymes. Enzymes as therapeutic agents-therapeutic use of asparaginase and streptokinase. Application of enzymes in industry- Industrial application of rennin, lipases, lactases, invertase, pectinases, papain.
Reading List (Print and Online)	**Enzymes** | MIT OpenCourseWare | Free Online Course Materials https://ocw.mit.edu/high-school/biology/exam-prep/chemistry-of-life/enzymes/ **Enzymology** https://onlinecourses.swayam2.ac.in/cec20_bt20/preview https://mooc.es/course/enzymology/ **The active site of enzymes** https://dth.ac.in/medical/courses/biochemistry/block-1/1/index.php **Enzymes and Enzyme Kinetics** https://www.lecturio.com/medical-courses/enzymes-and-enzyme kinetics.course#/ Mechanistic enzymology in drug discovery: a fresh perspective https://www.nature.com/articles/nrd.2017.219 Enzyme Biosensors for Biomedical Applications: Strategies for Safeguarding

	Analytical Performances in Biological Fluids https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4934206/
Self-Study	1.Mechanistic enzymology in drug discovery 2.Enzyme Biosensors for Biomedical Applications
Recommended Texts	1.Enzymes: Biochemistry, Biotechnology and Clinical chemistry, 2nd edition, 2007, Palmer T and Bonner P; Affiliated- East West press private Ltd, New Delhi 2.Fundamentals of Enzymology, 3rd edition, 2003, Price NC and Stevens L; Oxford University Press, New York 3.Voet's Biochemistry, Adapted ed, 2011,Voet,D and Voet JG; Wiley, India 4.Lehninger Principles of Biochemistry, 8th edition, 2021, .Nelson DL and Cox MM; WH Freeman & Co, New York 5. Biochemistry, Berg JM, Stryer L, Gatto,G, 8th ed, 2015;WH Freeman & Co., New York. 6.Enzyme Kinetics and Mechanism; Cook PF, Cleland W, ;2007; Garland Science, London

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

Methods of assessment:

Recall (K1) - Simple definitions, MCQ, Recall steps, Concept definitions.

Understand/ Comprehend (K2) - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.

Application (K3) - Suggest idea/concept with examples, Solve problems, Observe, Explain.

Analyse (K4)- Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas

Evaluate (K5) - Longer essay/ Evaluation essay, Critique or justify with pros and cons.

Create (K6)- Check knowledge in specific or offbeat situations, Discussion.

Mapping with Programme Outcomes:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	**S**	**M**	**S**	**L**	**M**	**S**	**L**	**S**	**S**	**M**
CO 2	**S**	**S**	**S**	**S**	**M**	**M**	**L**	**S**	**S**	**S**
CO 3	**S**	**S**	**S**	**S**	**M**	**M**	**M**	**S**	**S**	**S**
CO 4	**S**	**S**	**S**	**S**	**M**	**M**	**M**	**S**	**S**	**S**
CO 5	**S**	**S**	**S**	**S**	**M**	**L**	**M**	**S**	**S**	**S**

S-Strong M-Medium L-Low

Course code 23MBC2C2	COREPAPERV	
Title of the Course:	**CELLULAR METABOLISM**	
Credits:	**4**	**Hours:4**
Pre-requisites	Basic knowledge on biochemical reactions such as addition, deletion, rearrangement, transfer and breaking of bonds	
Course Objectives	1. Familiarize on blood glucose homeostasis 2. Provide an insight into the metabolic path way of glycogen, glycoprotein, mucopolysaccharide and peptidoglycan with clinical correlation wherever required 3. Inculcate knowledge on nucleotide metabolism and disorders associated with it 4. Provide a platform to understand the versatile role of PLP in amino acid degradation, formation of specialized products and disorders associated with ammonia detoxification 5. Educate on heme and sulphur metabolism with associated clinical manifestation	
Course Outcomes	**On successful completion of this course, students should be able to:** CO1. Appreciate the modes of synthesis and degradation of glucose and will be able to justify the pros and cons of maintain the blood sugar level (K1, K2, K5) CO2. Gain knowledge on polysaccharide metabolism and glycogen storage disease (K1, K2, K5) CO3. Acquaint with the making and braking of nucleotides (K1,K2,K4) CO4. Differentiate the diverse reaction a particular amino acid can experience (K1,K2,K3) CO5. Correlate the disturbance of metabolic reactions to clinical manifestations with reference to heme and sulphur metabolism (K1, K2, K4, K5)	
Units		
Unit I	Glycolysis – aerobic and anaerobic, inhibitors, and regulation. Feeder pathway- entry of hexoses into glycolysis, Galactosemia, fructosuria, Pyruvate dehydrogenase complex-mechanism and regulation. Glyoxalate cycle and its regulation. Gluconeogenesis- source, key enzymes, reaction sequence and its regulation. Blood glucose homeostasis and the role of hormones. Pentose phosphate pathway-significance and its regulation. Metabolism of glycogen and its regulation.Biosynthesis of N-linked and O-linked glycoproteins, mucopolysaccharides, Chondroitin sulphate.	

Unit II	Oxidation of fatty acids-oxidation of saturated and unsaturated fatty acids (α, β & ω oxidation) Oxidation of fatty acids with odd and even numbered carbon atoms. Regulation of β oxidation. Ketogenesis and its regulation. Biosynthesis of fatty acid–saturated and unsaturated, chain elongation, regulation. Biosynthesis of prostaglandins, thromboxanes and leukotrienes and hydroxyl eicosanoic acids. Biosynthesis and degradation of triacylglycerol, phosphoglycero lipids-lecithin, cephalin, plasmalogens and phosphatidyl inositol, Sphingolipid-sphingomyelin, cerebrosides, sulfatides, and gangliosides. Cholesterol biosynthesis and its regulation. Lipoprotein metabolism-chylomicrons, VLDL, HDL and LDL.
Unit III	Metabolism of nucleotides- *De novo* synthesis and salvage pathways of purine and pyrimidine nucleotides. Regulation and inhibitors of nucleotide biosynthesis. Role of ribonucleotide reductase and its regulation. Degradation of purine and pyrimidine nucleotides.
Unit IV	Biosynthesis of non- essential amino acids.- Role and biological significance of glutamate dehydrogenase, glutamine and asparagine synthetase, lysine, proline and phenylalanine hydroxylase. Interconversion of amino acids - proline to glutamate, methionine to cysteine, serine to glycine. Biosynthesis of spermine and spermidine. Degradation of amino acids –glucogenic and ketogenic amino acids. Formation of acetate from leucine and aromatic amino acid, pyruvate from cysteine, threonine and hydroxy proline, α-keto glutarate from histidine and proline, succinate from methionine, threonine, valine and isoleucine, Oxaloacetate from aspartate, glycine and serine.
Unit V	Biosynthesis and degradation of heme. Jaundice-classification, pathology and Differential diagnosis Oxidation and reduction of inorganic sulphur compounds by microbes and plants. Sulpho transferases and their biological role-rhodanases, sulphatases , 3-mercapto pyruvate sulphur transferases. Mucopolysaccharidoses - Hunter syndrome, Sanfilippo syndrome and Maroteaux-Lamy syndrome. Oxidation of cysteine to sulphate and inter conversion of sulphur compounds.
Reading List (Print and Online)	1. https://www.embopress.org/doi/full/10.1038/msb.2013.19 2. https://people.wou.edu/~guralnl/450Glycogen%20metabolism.pdf 3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3243375/ 4. https://www.researchgate.net/publication/334458898_Urea_Cycle 5.https://www.researchgate.net/publication/51233381_Heme_biosynthesis_and_its_regulation_Towards_understanding_and_improvement_of_heme_biosynthesis_in_filamentous_fungi 6.https://www.researchgate.net/publication/349746691_Microbial_Sulfur_Metabolism_and_Environmental_Implications
Self-study	1. Cori's Cycle and Glucose- Alanine Cycle 2. Coenzymes involved in Methanogenesis
Books Recommended	1.David L.Nelson and Michael M.Cox (2012) Lehninger Principles of Biochemistry (6th ed), W.H.Freeman 2.Voet.D and Voet. J.G (2010) Biochemistry , (4th ed), John Wiley & Sons, Inc.

	3.Metzler D.E (2003). The chemical reactions of living cells (2nd ed), Academic Press. 4. Zubay G.L (1999) Biochemistry , (4th ed), Mc Grew-Hill. 5. Textbook of Biochemistry with Clinical Correlations, 7th Edition,Thomas M. Devlin (Editor), Wiley 6. Human Biochemistry – James M.Orten&Otto.W.Neuhan- 10th edn-The C.V.Mosby Company

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

Methods of assessment:

Recall (K1) - Simple definitions, MCQ, Recall steps, Concept definitions.

Understand/ Comprehend (K2) - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.

Application (K3) - Suggest idea/concept with examples, Solve problems, Observe, Explain.

Analyse (K4)- Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas

Evaluate (K5) - Longer essay/ Evaluation essay, Critique or justify with pros and cons.

Create (K6)- Check knowledge in specific or offbeat situations, Discussion.

Mapping with Programme Outcomes:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	**S**	**M**	**S**	**M**	**S**	**M**	**S**	**S**	**S**	**M**
CO 2	**S**	**M**	**S**	**S**	**S**	**M**	**S**	**S**	**S**	**M**
CO 3	**S**	**M**	**S**	**S**	**S**	**M**	**S**	**S**	**S**	**S**
CO 4	**S**	**M**	**S**	**M**	**S**	**M**	**S**	**S**	**S**	**M**
CO 5	**S**	**M**	**S**	**S**	**S**	**M**	**S**	**S**	**S**	**S**

S-Strong M-Medium L-Low

Course code 23MBC2C3	CORE PAPER – VI	
Title of the Course:	**CLINICAL BIOCHEMISTRY**	
Credits:	**4**	**Hours:4**
Pre-requisites, if any:	The student should have a basic knowledge of body fluids and their composition and metabolism; anatomy and physiology of vital organs.	
Course Objectives	1. To understand the need and methods of various biological sample collection. 2. To explicitly understand the etiopathogenesis, symptoms and complications of metabolic and hormonal disorders and the relevant diagnostic markers 3. To emphasize the diagnostic significance of serum enzymes in different pathologies and other Laboratory investigations of diagnostic importance so as to differentiate normal from disease 4. To conceive the role of inherited genes in inborn errors of metabolism and methodologies pertaining to *in utero* diagnosis and post-natal screening. 5. To get updated about electrolyte and hormonal imbalances and the biochemical tests to diagnose them.	
Course Outcomes	CO1. To appreciate the biological significance of sample collection and awareness of the diagnostic/screening tests to detect common non-communicable diseases so as to understand role of laboratory investigations for biochemical parameters and understand the disorders associated with blood cells CO2. To understand the etiology of metabolic diseases like diabetes and atherosclerosis and avoid such lifestyle disorders by healthy eating and correlate the symptoms with underlying pathology based on diagnostic and prognostic markers. CO3. To understand the diagnostic application of serum/plasma enzymes to correlate their levels with the organ pathologies associated with specific diseases. CO4. To appreciate the role of pre and post-natal diagnosis leading to healthy progeny CO5. To link the serum hormone levels and clinical symptoms with underlying hormonal disturbances. To review the onward transmission of signal via downstream signaling molecules from cell surface to the nucleus by different pathways by comparing and contrasting them and critically evaluate the network between them resulting in the biological outcome.	
Units		
Unit I	Biochemical investigations in diagnosis, prognosis, monitoring, screening: Specimen collection – blood, (primary /Secondary specimen)., urine and CSF. Preservation of biological specimens -blood, urine, CSF and amniotic fluid. ; . Biological reference ranges; Disorders of blood cells: Hemolytic, iron deficiency and aplasticanemia and diagnosis, sickle cell anaemia, thalassemia HBA1C variants. Porphyrias, Thrombocytopenia, Causes of leucopenia, leukemia and leucocytosis. Disorders of blood clotting mechanism - Von willebrand's disease, Hemophilia A, B and C,	

	diagnostic test for clotting disorders, D-dimer and its clinical significance.
Unit II	Diabetes mellitus: pathology and complications: Acute changes; Chronic complications: Diabetic nephropathy, neuropathy, retinopathy and Diabetic foot ulcers, Random/Fasting/PP glucose testing, Impaired glucose tolerance (IGT), Impaired fasting glucose (IFT), Diagnosis-by GTT, Pre-diabetes, Gestational DM ,Glycosylated Haemoglobin (HBA1c) ; Glycated albumin., Hypoglycaemia and critical alert value for glucose. Markers of complications of Diabetes mellitus: Metabolic syndrome, Lipid profile &lipoproteinemia, Atherosclerosis, Diabetic nephropathy, Micralbuminuira, eGFR. Point of care testing for glucose (Glucometers) and continuous glucose monitoring (CGM) : principle and its use. Major groups of anti-diabetic drugs. Diet and life style modifications
Unit III	Diagnostic Enzymology: Clinically Important Enzymes and Isoezyme as diagnostic markers: Clinical significance of AST, ALT, ALP, ACP, CK, γ-GT, amylase, pseudocholinesterase and their pattern in .Myocardial infarction; Liver disease, Bone disease, Muscle disease, Cancer (tumor markers), GI tract pancreatitis); Enzymes as therapeutic agents. Pre- and post-natal testing: Amniocentesis, prenatal detection of inborn errors of metabolism in developing fetus- Autosomal recessive mode of inheritance- cystic fibrosis, X linked recessive inheritance-Duchenne muscular dystrophy. New born screening (NBS) for In born errors of metabolism, Tandem mass spectrometry application in NBS
Unit IV	Liver function tests: Liver function test panel, Fatty liver . Plasma protein changes in liver diseases. Hepatitis A ,B and C. Cirrhosis and fibrosis. Portal hypertension and hepatic coma.Acute phase proteins -CRP, Haptoglobins, α-fetoprotein, ferritin and transferrin and their clinical significance, Interpreting serum protein electrophoresis. Inflammatory markers (cytokines such as TNF-alpha IL6 and others)
Unit V	Renal function tests - tests for glomerular and tubular function-Acute and chronic renal failure-Glomerulonephritis, Nephrotic syndrome, uraemia-urinary calculi-Nephrocalcinosis and Nephrolithiasis-causes, pathology and symptoms. Chronic kidney disease. Dialysis-Hemodialysis and peritoneal dialysis. Hormonal disorders and diagnostics: T3, T4 and TSH in the diagnosis of thyroid disorders; Diagnostic methods for disorders associated with adrenal, pituitary and sex hormones - Addison's disease, Cushing's syndrome, pituitary tumour, Hypopituitarism, Hypogonadism
Reading List (Print and Online)	1.Utility of HIL in Clinical Chemistry: https://www.aacc.org/science-and-research/clinical-chemistry-trainee-council/trainee-council-in-english/pearls-of-laboratory-medicine/2018/utility-of-hil-in-clinical-chemistry 2. Pre, Post and Analytical Errors in Clinical Chemistry laboratory DOI: 10.7860/NJLM/2016/22587:2173 https://doi.org/10.2147/JMDH.S286679 3. Standards of Medical Care in Diabetes—2022 Abridged for Primary Care Providers https://diabetesjournals.org/clinical/article/40/1/10/139035/Standards-of-Medical-Care-in-Diabetes-2022 https://doi.org/10.2337/diaspect.16.1.32 http://www.ngsp.org/ 4. Quality control in clinical laboratory

	https://www.researchgate.net/publication/335830829_Quality_Control_in_a_Clinical_Laboratory https://labpedia.net/quality-control-of-the-clinical-laboratory/ https://journals.sagepub.com/doi/full/10.1016/j.jala.2008.12.001 https://doi.org/10.1016/B978-0-12-407821-5.00004-8 https://www.westgard.com/clia.htm https://www.labroots.com/webinar/bio-rad-unity-solution-molecular-quality-control-data-management
Self-Study	1. Potential sources of variability in the estimation of the analytes: Pre-analytical phase: acceptance rejection criteria in terms of haemolysis/icteric/lipemia (HIL) interferences Analytical phase: Linearity, detection limits precision, accuracy, specificity, sensitivity; Total Allowable Error. (Definitions and examples). Post-analytical phase : Units of reporting of clinical chemistry parameters- 2. Interpretation of results in clinical chemistry based on laboratory investigations and quality control: • critical / alert values • American Diabetes Association (ADA) Standards of Medical Care in Diabetes (yearly update); HBA1C testing :NGSP • Case studies to review • Quality control for clinical chemistry in laboratory
Recommended Texts	1. ThomasM.Devlin (2014) Textbook of Biochemistry with Clinical Correlations (7th ed). John Wiley & Sons 2. Montgomery R, Conway TW, Spector AA (1996),Biochemistry: A Case-Oriented Approach (6th ed), Mosby Publishers, USA. 3. Tietz Fundamentals of Clinical Chemistry and Molecular Diagnostics (2018) (8th ed),Saunders 4. Dinesh Puri, (2020) Text book of Biochemistry: A clinically oriented approach – 4th Edition, Elsevier. 5. 5. M.N.Chatterjee and Rana Shinde (2012).Textbook of Medical Biochemistry (8th ed), Jaypee Brothers Medical Publishers. 6. Clinical Case Discussion In Biochemistry A Book On Early Clinical Exposure (ECE), Poonam Agrawal , 2021, CBS Publishers & distributors pvt. Ltd

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total
10	**10**	**5**	**75**	**100**

Methods of assessment:

Recall (K1) - Simple definitions, MCQ, Recall steps, Concept definitions.

Understand/ Comprehend (K2) - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.

Application (K3) - Suggest idea/concept with examples, Observe, Explain.

Analyse (K4)- Finish procedure in stepwise manner, Differentiation between various ideas, Map knowledge

Evaluate (K5) - Longer essay/ Evaluation essay, Critique or justify with pros and cons.

Create (K6)- Check knowledge in specific or offbeat situations, Discussion, Debating, Presentation

Mapping with Programme Outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S	S	M	S	S	S	S	M	M	S
CO 2	S	M	S	M	S	S	S	M	M	M
CO 3	S	S	S	S	S	M	S	S	M	M
CO 4	S	M	M	M	S	M	S	S	S	M
CO 5	S	M	S	M	S	S	S	S	S	S

S-Strong M-Medium L-Low

Course code 23MBC2P1	CORE PAPER – VII	
Title of the Course:	**LABORATORY COURSE ON CLINICAL BIOCHEMISTRY**	
Credits:	**4**	**Hours:8**
Pre-requisites, if any:	Knowledge on basic principles, Instrumentation of Biochemical techniques and metabolic reactions	
Course Objectives	1. To instill skill in students enabling them to apprehend the wider knowledge about principles and techniques to be employed for the investigation of biological samples, clinical approach, normal values of biochemical constituents and clinical interpretations. 2. To inculcate the knowledge of collection, preservation of blood sample and learning various hematological parameters and their significance. 3. To perform experiments to assess liver functions. And also to study the marker enzymes of liver 4. To evaluate lipid profile and assess their relation to cardiac function. 5. To perform experiments to estimate blood glucose and glycosylated hemoglobin. 6. To perform urine analysis, estimate BUN and clearance test to assess renal function . 7. To learn basic immunotechnniques antigen –antibody reactions. 8. To perform data analysis in using MS Excel 9. To introduce visit to hospital so that students may be aware of Phleobotomy ,Collection and storage of specimen, Good laboratory practices, Automation and current methods adopted in the diagnostic labs	
Course Outcomes	After completion of the course, the students should be able to: **CO1.**The student will be able to acquire knowledge and skill in hematology techniques. They will get familiar with methods and knowledge to interpret the electrolyte concentration in serum (K1,K2,K3,K4,K5) **CO2.** The student will be able to assess the Liver Function and interpret the biochemical investigation in a given clinical situation (K1,K2,K3,K4,K5) **CO3**.Skill to perform the Renal function test to assess the function of Kidney and report the abnormal parameters with reference range will be achieved by the student (K1,K2,K3,K4,K5) **CO4**. To estimate the blood glucose content and lipid profile , to evaluate the alterations and record the observation in accordance to reference range will be acquired by the student (K1,K2,K3,K4,K5,K6) **CO5:** The Group Experiments will support them to acquire practical skills to work in health care sector and assist them to understand the automation process in clinical labs (K1,K2,K3,K4,K5,K6)	
Units		
Unit I	Haematology: RBC count, WBC count – total and differential count, ESR, PCV, MCV. Bleeding Time, Clotting Time and Estimation of hemoglobin.	

	Determination of Electrolytes :Sodium, Potasium and Calcium
Unit II	Liver function test: Estimation of bilirubin – direct and indirect. Estimation of plasma protein, A/G ratio, Thymol turbidity test, Prothrombin Time (PT),Assay of serum glutamate oxaloacetate transaminase, alkaline phosphatase, Gamma-glutamyltransferase (GGT), isoenzyme separation of LDH by electrophoresis.
Unit III	Renal function test: Collection and Preservation of Urine sample Qualitative tests for normal and pathological components of urine. BUN: Estimation of blood Urea, creatinine, and uric acid. Urea Clearance test
Unit IV	Estimation of blood glucose by orthotoluidine and glucose oxidase method. Determination of glycosylated Hb. Glucose tolerance test. Kit method Lipid profile: Estimation of cholesterol by Zak's method, lipoprotein profile, estimation of ketone bodies, estimation of triglycerides, free fatty acids and phospholipids.
Unit V	Group Experiments a. Antigen – Antibody Reaction - HCG kit method , RA kit method b. Phlebotomy –Venipuncture , Different techniques of venipuncture c. Collection of blood ,Serum or Plasma separation and Storage d. Automation in Clinical Biochemistry -Autoanalyser ,Semiautoanalyser
Reading List (Print and Online)	1.https://www.researchgate.net/publication/260182512_ Practical_Manual_in_Biochemistry_and_Clinical_Biochemistry 2.https://main.icmr.nic.in/sites/default/files/upload_documents/GCLP_Guidelines_2020_Final.pdfhttps://www.westgard.com/clia.html 3. https://www.researchgate.net/publication/263929434_Biochemistry 4. https://ucms.ac.in/Lectures-C-2020/Renal%20function%20Tests%20-%20PPT.pdf 5. https://youtu.be/i2PfjEks4GQ 6.https://www.euro.who.int/__data/assets/pdf_file/0005/268790/WHO-guidelines-on-drawing-blood-best-practices-in-phlebotomy-Eng.pdf
Self-Study	1. Laboratory handling of human biological specimen 2.Automation in Clinical Biochemistry
Recommended Texts	1Practical Clinical Biochemistry- Varley's by Alan H Gowenlock, published byCBS Publishers and distributors, India Sixth Edition ,1988. 2. Manipal Manual of Clinical Biochemistry (For Med.Lab.AndMsc Stud.) 2013 (4 Edition) 3. Case Oriented Approach in Biochemistry-Dr. Rajesh Kawaduji Jambhulkar, Dr. Abhijit D. Ninghot: 2019 First Edition 4. Medical Lab Technology Vol I& II, Kanai L Mukerjee New Delhi: Tata McgrawHill Publishing Company, 1996. 5. Practical Biochemistry – Plummer, New Delhi: Tata Mcgraw Hill PublishingCompany, 2000. 6. Introductory practical Biochemistry – S.K. Sawhney, Randhir Singh, 2nd ed,2005.

Method of Evaluation:

Test I	Test II	Assignment	End Semester	Total	Grade

			Examination		
10	10	5	75	100	

Methods of assessment:

Recall (K1) - Simple definitions, MCQ, Recall steps, Concept definitions.

Understand/ Comprehend (K2) - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.

Application (K3) - Suggest idea/concept with examples, Solve problems, Observe, Explain.

Analyse (K4) – Problem-saving questions, Finish a procedure in many steps, Differentiate between various ideas.

Evaluate (K5) - Longer essay/ Evaluation essay, Critique or justify with pros and cons

Create(K6) – Check knowledge in specific or offbeat situations. Discussion.

Mapping with Programme Outcomes:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	**S**	**S**	**S**	**S**	**M**	**S**	**L**	**S**	**M**	**S**
CO 2	**S**	**S**	**S**	**S**	**M**	**S**	**L**	**S**	**M**	**S**
CO 3	**S**	**S**	**S**	**S**	**M**	**S**	**M**	**S**	**M**	**S**
CO 4	**S**	**S**	**S**	**S**	**M**	**S**	**M**	**S**	**S**	**S**
CO 5	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**

S-Strong M-Medium L-Low

Course code 23MBC2E1	CORE ELECTIVE PAPER - II	
Title of the Course:	ENERGY AND DRUG METABOLISM	
Credits:	3	Hours:3
Pre-requisites	Basic knowledge on biochemical reactions such as addition, deletion, rearrangement, transfer and breaking of bonds	
Course Objectives	1. Familiarize on concepts of enthalpy, entropy, free energy, redox system, biological oxidation and high energy compounds 2. Provide an insight into the relationship between electron flow and phosphorylation 3. Inculcate knowledge on processes involved in converting light energy to chemical energy and associated food production by autotrophs 4. Provide a platform to understand the versatile role of Krebs cycle, transport of NADH across mitochondrial membrane and energetics 5. Educate on the various phases xenobiotic metabolism	
Course Outcomes	**On successful completion of this course, students should be able to:** After completion of the course, the students should be able to: **CO1.** Appreciate the relationship between free energy and redox potential and will be able to justify the role of biological oxidation and energy rich compounds in maintaining the energy level of the system (**K1,K2,K3,K4**) **CO2.** Gain knowledge on role of mitochondria in the production of energy currency of the cell **(K1, K2, K5, K6)** **CO3.** Acquaint with the process of photosynthesis **(K1,K2,K5)** **CO4.** Comprehend on the diverse role of TCA cycle and the energy obtained on complete oxidation of glucose and fatty acid **(K1,K2,K4,K5)** **CO5.** Correlate the avenues available to metabolize the xenobiotics (**K1, K2,K4,K5)**	
Units		
Unit I	Thermodynamic- principles in biology- Concept of entropy, enthalpy and free energy change. Redox systems. Redox potential and calculation of free energy. Biological oxidation – Oxidases, dehydrogenases, hydroperoxidases, oxygenases. Energy rich compounds – phosphorylated and non-phosphorylated. High energy linkages.	
Unit II	Electron transport chain-various complexes of ETC, Q-cycle. Inhibitors of ETC. Oxidative phosphorylation-P/O ratio, chemiosmotic theory. Mechanism of ATP synthesis - role of F0-F1 ATPase, ATP-ADP cycle. Inhibitors of oxidative phosphorylation ionophores, protonophores .Regulation of oxidative phosphorylation	
Unit III	Light reaction-Hills reaction, absorption of light, photochemical event. Photo ETC-cyclic and non-cyclic electron flow. Photophosphorylation-role of CF0-CF1 ATPase. Dark reaction- Calvin cycle, control of C3	

	pathway, and Hatch-Slack pathway (C4 pathway), Photorespiration. Synthesis and degradation of starch
Unit IV	Interconversion of major food stuffs. Energy sources of brain, muscle, liver, kidney and adipose tissue. Amphibolic nature of Citric acid cycle. Anaplerotic reaction. Krebs cycle, Inhibitors and regulation of TCA cycle. Transport of extra mitochondrial NADH – Glycerophosphate shuttle, malate aspartate shuttle. Energetics of metabolic pathways – glycolysis, (aerobic and anaerobic) ,citric acid cycle, beta oxidation
Unit V	Activation of sulphate ions – PAPS, APS, SAM and their biological role. Metabolism of xenobiotics – Phase I reactions – hydroxylation, oxidation and reduction. Phase II reactions – glucuronidation, sulphation, glutathione conjugation, acetylation and methylation. Mode of action and factors affecting the activities of xenobiotic enzymes.
Reading List (Print and Online)	1.https://chemed.chem.purdue.edu/genchem/topicreview/bp/ch21/gibbs.php 2.https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7767752/#:~:text=The%20mitochondrial%20electron%20transport%20chain,cellular%20ATP%20through%20oxidative%20phosphorylation. 3. https://www.researchgate.net/figure/Oxidative-phosphorylation-in-mitochondrial-electron-transport-chain-ETC-and-proton_fig1_230798915 4.https://www.lyndhurstschools.net/userfiles/84/Classes/851/photosynthesis%20light%20&%20dark%20reactions%20ppt.pdf?id=560837 5.https://bajan.files.wordpress.com/2010/05/amphibolic-nature-of-krebs-cycle.pdf 6.https://www.sciencedirect.com/topics/medicine-and-dentistry/xenobiotic-metabolism#:~:text=Xenobiotic%20metabolism%20can%20be%20defined,more%20readily%20excreted%20hydrophilic%20metabolites
Self-Study	1. Calculation of Keq and △ G 2. Interrelationship of carbohydrate, protein, and fat metabolism-role of acetyl CoA
Recommended Texts	1.David L.Nelson and Michael M.Cox (2012) Lehninger Principles of Biochemistry (6th ed), W.H.Freeman 2. Robert K. Murray, Darryl K. Granner, Peter A. Mayes, and Victor W. Rodwell (2012), Harper's Illustrated Biochemistry, (29th ed), McGraw-Hill Medical 3. Metzler D.E (2003). The chemical reactions of living cells (2nd ed), Academic Press. 4. Zubay G.L (1999) Biochemistry , (4th ed), Mc Grew-Hill. 5. Devlin RM (1983) Plant Physiology (4th ed), PWS publishers 6.Taiz L , Zeiger E (2010), Plant Physiology (5th ed), Sinauer Associates, Inc

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

Methods of assessment:

Recall (K1) - Simple definitions, MCQ, Recall steps, Concept definitions.

Understand/ Comprehend (K2) - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.
Application (K3) - Suggest idea/concept with examples, Solve problems, Observe, Explain.
Analyse (K4)- Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas
Evaluate (K5) - Longer essay/ Evaluation essay, Critique or justify with pros and cons.
Create (K6)- Check knowledge in specific or offbeat situations, Discussion.
Mapping with Programme Outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S	S	S	M	S	M	S	S	S	M
CO 2	S	S	S	S	S	S	S	S	S	S
CO 3	S	S	S	S	S	S	S	S	S	S
CO 4	S	M	S	M	S	M	S	S	S	L
CO 5	S	M	S	S	S	M	S	S	S	S

S-Strong M-Medium L-Low

Course code 23MBC2E2	ELECTIVE PAPER-III	
Title of the Course:	**NUTRITIONAL BIOCHEMISTRY**	
Credits:	**3**	**Hours:3**
Pre-requisites, if any:	**BASIC KNOWLEDGE ON FOOD, NUTRITION & DIETETICS, AND METABOLISM OF NUTRIENTS.**	
Course Objectives	1. To understand basic concepts involved in growth , health, nutrition, physiology and metabolism 2. To discuss the concepts and applications of nutrition in correlation with biochemistry 3.To define nutritional needs in healthy individuals and modification of diet during illness.	
Course Outcomes	After completion of the course, the students should be able to: CO1. Plan a balanced diet based on an individual's energy requirement, Assess nutritional status of an individual(K3, K4, K5) CO2. Describe the biochemical , physiological and nutritional functions of macronutrients and their integrated role. Understand the role played by antinutritional factors(k! to K6) CO3. Evaluate the functions of vitamins and minerals ,and fluids and electrolyte balance in different physiological states and in sports persons(K1 to K6) CO4. Identify nutritional deficiency conditions , its prevention and dietary management((K3,K4) CO5. Acquire knowledge about the importance of balanced diet and diet therapy (k5,K6)	
Units		
Unit I	Basic concepts - Nutrition - Food groups and balanced diet. Novel Foods. Calorific value of foods: Direct and indirect calorimetry. Empty calories. Basal metabolic rate: Factors affecting BMR. SDA and physical activity. Calculation of day's energy requirement. Assessment of nutritional status. Lactose intolerance. Nutritional requirement and biochemical changes in different physiological states -infancy, childhood, pregnancy, lactation, and ageing. Sports nutrition.	
Unit II	Elements of nutrition - Plant and animal sources of simple and complex carbohydrates, fats and proteins and their requirement. Biological significance, deficiency and toxicity of macronutrients and micronutrients. Role of dietary fibre. Protein sparing action of carbohydrates and fats. Essential amino acids. Essential fatty acids. Effects of naturally occurring food toxins, preservatives, additives, alcohol and tobacco on health.	
Unit III	Vitamins and Minerals- Dietary sources, classification, biochemical functions, requirements, absorption, metabolism and excretion. Vitamin B complex as coenzyme. Nutritional significance of dietary calcium, phosphorus, magnesium, iron, iodine, zinc and copper.	
Unit IV	Malnutrition - Diseases arising due to Protein - Calorie Malnutrition and undernutrition (Kwashiorkor and Marasmus), Prevention of malnutrition. Deficiency diseases associated with vitamin B complex, vitamin C and A, D, E & K vitamins - Mineral deficiency diseases -	

	aetiology, sign and symptoms and dietary supplementation. Enrichment and fortification (vitamins and minerals)
Unit V	Nutrition in diseases - Aetiology, signs and symptoms , treatment and dietary management during fever(Typhoid and Malaria) and infectious diseases(COVID-19), Jaundice, hyper acidity (Ulcer), Atherosclerosis, Hypertension, kidney diseases and diabetes in adults. Starvation and Obesity. Inter-relationship of nutrition, infection, immunity and poverty
Reading List (Print and Online)	1. https://www.jmedscindmc.com/article.asp?issn=1011-4564;year=2014;volume=34;issue=5;spage=211;epage=213;aulast=Shrivastava 2. https://www.researchgate.net/figure/Relationship-between-malnutrition-infection-and-immunity-Malnutrition-is-considered-the_fig1_280722727 3. https://en.wikipedia.org/wiki/Novel_food 4. https://www.chemicalsafetyfacts.org/preservatives/ https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/food-enrichment
Self-Study	1. Antabuse drugs and food 2. Selection of foods and market visit, reading and understanding the food labels
Recommended Texts	1. Srilakshmi. E .(2016) Nutrition Science, New Age International Publishers. 2. Mahan, Kathleen L. (2004) Krause's Food, Nutrition and Diet Therapy, W.B.Saunder's 11th Edition 3. Andreas M. Papas (1998). Antioxidant Status, Diet, Nutrition, and Health (1st ed) CRC Press. 4. M. Swaminathan (1995) Principles of Nutrition and Dietetics. Bappco 5. Margaret Mc Williams (2012). Food Fundamentals (10th ed) Prentice Hall 6. Tom Brody (1998) Nutritional Biochemistry (2nd ed). Academic Press, USA

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	**10**	**5**	**75**	**100**	

Methods of assessment:

Recall (K1) - Simple definitions, MCQ, Recall steps, Concept definitions.
Understand/ Comprehend (K2) - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.
Application (K3) - Suggest idea/concept with examples, Solve problems, Observe, Explain.
Analyse (K4) – Problem-saving questions, Finish a procedure in many steps, Differentiate between various ideas.
Evaluate (K5) - Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create(K6) – Check knowledge in specific or offbeat situations. Discussion.

Mapping with Programme Outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10

CO 1	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**M**	**M**
CO 2	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**M**	**M**
CO 3	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**M**	**M**
CO 4	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**M**	**L**
CO 5	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**M**	**M**

S-Strong M-Medium L-Low

Course code 23MBC2S1	SEC -I	
Title of the Course:	**FUNDAMENTAL OF MEDICAL LABORATORY TECHNOLOGY**	
Credits:	**2**	**Hours:4**
Pre-requisites, if any:	Comprehensive Knowledge ofbiochemistry, microbiology and hematology	
Course Objectives	The candidates undertaking this course will 1. Undergo training in all fields of laboratory medicine (Biochemistry, Microbiology,Pathology and Blood bank departments respectively 2. Handle fully automated analysers 3. Be able to collect and prepare the sample 4. Understand and perform special stains and smears 5. Understand and perform basic cytology and haematology procedures 6. Perform Quality control procedures	
Course Outcomes	**On completion of the course students will be able to** **CO1**. Work under different specialities of Laboratory Medicine (Biochemistry, Microbiology, Pathology and Blood bank departments respectively) **CO2**.Apply knowledge and technical skills associated with medical laboratory technology for delivering quality clinical investigation support **CO3**. Perform routine clinical laboratory procedures within acceptable quality control parameters in haematology and biochemistry **CO4**. Operate and maintain laboratory equipment's utilizing appropriate quality control and safety measures **CO5** Recognize the impact of laboratory test in a global and environmental context.	
Units		
Unit I	**Introduction to clinical laboratory** Basic laboratory principles - Code of conduct of medical laboratory personnel. The use of the laboratory - Basic laboratory principles - Code of conduct of medicallaboratory personnel -Organization of clinical laboratory and role of medical laboratorytechnician - Safety measures - Medical laboratory professional and professionalism inlaboratory workers - clinic borne infection and personnel hygiene	
Unit II	**Common Laboratory Equipment's** Incubator, Hot Air Oven, Water Bath - Anaerobic Jar, Centrifuge, Autoclave -Microscope - Fundamentals of Microscopy, Resolution & Magnification, Light Microscopy, Electron Microscopy- Glassware – Description of Glassware, its use, handling and care	

Unit III	**Basic Steps for Drawing A Blood Specimen** Requirement of Blood Collection - Blood collection - Phlebotomy - Sampling errors - Collection and preservation of biological fluids - Anticoagulants - Preservation of samples - Chemical preservatives - Process of analysing the specimens - The laboratory report..
Unit IV	**Preparation of Reagents & Quality control** Buffer and pH- Preparation of reagents : Normal , per cent and Molar solution - normal saline -Methods of measuring liquids- Clinical Laboratory records- Modern Laboratory set up - Quality control: Accuracy, Precision, and Reference values.
Unit V	**Manual Vs Automation in Clinical Laboratory** Types of analyzers - Semi-auto analyzer - Batch analyzer - Random Access autoanalyzers. Steps in the automated systems - Responsibilities of a technician in the maintenance of the analyzers.
Unit VI	**Characteristics of laboratory Substances** The chemical composition, structure, and properties of substances. The chemical processes and transformations that they undergo including the use of chemicals and their interactions, danger signs, production techniques, and disposal methods
Recommended Texts	1. Fischbach, 2005. Manual of lab and diagnostic tests, Lippincott Williams Wilkins, New York. 2. Gradwohls, 2000. Clinical laboratory methods and diagnosis. (ed) Ales C. Sonnenwirth and leonardjarret, M.D.B.I., New Delhi. 3. J Ochei and Kolhatkar, 2002. Medical laboratory science theory and practice, Tata McGraw- Hill, New Delhi. 4. Kanai L. Mukherjee, 2007, Medical laboratory technology Vol.1.Tata McGraw Hi

SEMESTER- III

Course code 23MBC3C1	**CORE PAPER - VIII**	
Title of the Course:	**INDUSTRIAL MICROBIOLOGY**	
Credits:	**4**	**Hours:4**
Pre-requisites, if any:	**Basic Knowledge of Microbiology and microbial techniques**	
Course Objectives	1. To gain knowledge of the structure, classification and use of microorganisms in various industries. 2. To know various fermenter designs, culture systems and the application of fermentation process in industry. 3. To understand the production and purification of fermented products and their industrial applications. **4.** Understand the basic concepts of food and agricultural **microbiology.**	
Course Outcomes	CO1.Students will be able to understand the structure and classification of microorganisms (K2 , K4) CO2.Gain knowledge of the uses of microorganisms in various industrial applications (K3 , K4) CO3.Understand the concepts of fermentation process, harvest and recovery. (K1 , K5) CO4.Students will know the types of microbial fermentation processes and their applications in pharmaceutical industry. (K2 , K3) CO5.Students will learn about the use of microorganisms in beverages, diary and food industries. (K3 , K6)	
Unit I	Structure of bacteria, fungi and viruses and their classification. Types and characteristics of microorganisms used in Industry (a) Food Industry (b) Chemical Industry (c) Pharmaceutical Industry	
Unit II	Fundamentals and principles of microbial fermentation techniques – application in industry and pharmaceutical Biochemistry. Fermentation – types, techniques, design and operation of fermenters including addition of medium. Types and characteristics of microorganisms, environmental conditions required for the growth and metabolism of industrially and pharmaceutically important microbes. Sterilization methods in fermentation techniques, air, gas, culture medium sterilization. Steam-filtration and chemicals. Types and constituents of fermentative culture medium and conditions of fermentations, Antifoaming devices.	
Unit III	Recovery and estimation of products of fermentation- Production of ethanol, acetic acid, glycerol, acetone, butanol and citric acid by fermentation. Production of Enzymes- amylase, protease, lipase,Production of pharmaceuticals by fermentation– penicillin, streptomycin, tetracycline, riboflavin, vitamin B12.Beverages-wine, beer and malt beverages.	
Unit IV	Food Microbiology: Production of dairy products-bread, cheese and yoghurt (preparation and their types). Food borne diseases- Bacterial and Non- Bacterial. Food preservation - Principles–Physical methods: temperature (low, high, canning, drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging, Chemical methods - salt, sugar, organic acids, SO_2, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins.	

Unit V	Agricultural Microbiology: General Properties of soil, microorganisms in soil – decomposition of organic matter in soil. Biogeochemical cycles, nitrogen fixation, Production of bio fertilizers and its field applications – Rhizobium, azotobacter, blue green algae, mycorrhizae, azospirilium, Production of biofuels (biogas- methane), soil inoculants.
Self-Study	• **Micro-organisms in food processing and pharma industries** • **Upstream and Downstream processes in Biopharma**
Reading List (Print and Online)	1. Industrial biotechnology: 2. https://nptel.ac.in/courses/102/105/102105058/ 3. Bioreactors: 4. https://nptel.ac.in/courses/102/106/102106053/ 5. Food Microbiology: 6. https://nptel.ac.in/courses/126/103/126103017/ 7. Agriculture Microbiology: 8. https://www.youtube.com/watch?v=f7UXyVImZ_c
Recommended Texts	1. Food Microbiology: An Introduction: 4th edition,Matthews KR, Kniel KE, Montville TJ; American Society for Microbiology 2. Food, Fermentation and Micro-Organisms,2nd edition, Charles, BW; Blackwell Science Ltd 3. Microbiology. 5th edition , Pelczar MJ, Chan ECS and Krieg NR; McGraw Hill Book Company. 4. Text book of Microbiology:11th edition, Ananthanarayanan R and Paniker CKJ; Universities Press (India) Pvt. Ltd. 5. Food Microbiology, 3rd edition, Frazier WC and Westhoff DC;TataMcGrawHill Publishing Company Ltd, New Delhi 6. New Methods of Food Preservation:1st edition, Gould GW; Springer Manual of Industrial Microbiology and Biotechnology: 3rd edition, Baltz

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

Methods of assessment:

Recall (K1) - Simple definitions, MCQ, Recall steps, Concept definitions.
Understand/ Comprehend (K2) - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.
Application (K3) - Suggest idea/concept with examples, Solve problems, Observe, Explain.
Analyse (K4)- Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas
Evaluate (K5) - Longer essay/ Evaluation essay, Critique or justify with pros and cons.
Create (K6)- Check knowledge in specific or offbeat situations, Discussion.

Mapping with Programme Outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S	S	M	S	S	S	M	M	S	S
CO 2	S	M	S	S	M	S	S	M	M	M
CO 3	S	M	L	S	M	M	S	S	M	S
CO 4	M	S	S	S	L	M	S	M	S	M
CO 5	S	S	M	S	S	M	M	S	S	S

S-Strong M-Medium L-Low

Course code 23MBC3C2	CORE PAPER –IX	
Title of the Course:	**MOLECULAR BIOLOGY**	
Credits:	4	**Hours:4**
Pre-requisites, if any:	Knowledge of the basics of genetics, cell biology and molecular biology.	
Course Objectives	1. To introduce the students to the process of inheritance, concepts of genes, genome, chromatin and chromosomes. 2. To impart a thorough understanding of the key events of molecular biology, including the mechanisms of DNA replication, transcription and translation along with DNA repair mechanisms. 3. To provide a detailed understanding of post transcriptional and posttranslational modifications and processing of eukaryotic RNA and proteins 4. To give a detailed explanation of transcriptional regulation with lac operon and tryptophan operon as examples 5. To impart adequate information of the types of regulatory RNAs along with key concepts of gene silencing	
Course Outcomes	After completion of the course, the students should be able to: **CO1:** Comprehend the organization of genomes, the molecular basis of DNA replication,recombination and transposition,the significance of these processes, the various ways in which the DNA can be damaged leading to mutations and lesions and the different ways in which they are repaired.(K1,K2,K3,K5) **CO2:** Gain knowledge about how genes are transcribed and translated in prokaryotes and eukaryotes and how these processes are regulated, recognize the nature of the genetic code and the various experimental approaches used to crack the code (K1,K2,K3,K4,K5) **CO3:** Acquire knowledge of the molecular basis of RNA processing and RNA splicing and the various human pathologies that can result from defects of RNA modification. (K1,K2,K4,K5) **CO4:** Comprehend the techniques of gene silencing and its applications.(K1,K2,K3,K4,K5,K6) **CO5:** Apply the knowledge they have gained in understanding the above vital life processes to enhancing their analytical and problem-solving skills and develop an interest to pursue high quality research. (K2,K3,K4,K5,K6)	
Unit I	Mendel's laws of inheritance-dominance-complete, incomplete and co-dominance, multiple alleles-gene mapping in haploids and diploids, recombination mapping- restriction mapping- modes of gene information transfer in bacterial- conjugation, transformation and transduction. The bacterial chromosome, the eukaryotic genome- chromosome structure – Histones, Nucleosome, chromatin- heterochromatin, euchromatin, chromatin remodeling, DNAase hypersensitive sites, genome organization – the C-value paradox, reassociation kinetics, repetitive sequences, gene amplification, telomeres, pseudogenes, split genes, organelle genomes – mitochondrial and chloroplast genome.	

Unit II	DNA replication and repair: Enzymes of replication, prokaryotic replication mechanisms, primosome& replisomes, eukaryotic DNA replication, the role of topoisomerases and telomerase, regulation of replication, difference between prokaryotic and eukaryotic replication. Mutations -Types of mutations, mechanisms of mutations, mutagenic agents. DNA repair mechanisms – Direct repair, excision repair, mismatch repair, recombination repair, SOS response, eukaryotic repair systems. Recombination and mobile genetic elements- the Holliday model, the general recombination in *E.coli*, site specific recombination, transposons and retroposons.
Unit III	Transcription – Prokaryotic transcription-subunits of RNA polymerase, E. coli promoters, sigma factor and promoter recognition, alternative sigma factors, initiation, elongation, Rho-dependent and independent termination of transcription. Eukaryotic transcription- Initiation, promoter elements, RNA polymerases, transcription factors, regulatory sequences in eukaryotic protein – coding genes, CpG islands, enhancers. Translation – organization of the ribosome, the genetic code, evidence for a triplet code, deciphering the genetic code, wobble hypothesis, deviation in the genetic code, unusual codons. activation, initiation, elongation and termination of translation in E. coli. The role of tRNA and rRNA, suppressor tRNAs and inhibitors of protein synthesis., Comparison of prokaryotic translation with eukaryotic translation.
Unit IV	Regulation of gene expression in prokaryotes-– Positive and negative control, the lac operon, identification of operator and regulator sequences by mutations, induction and repression, Foot-printing and gel-shift assays for identification of protein-DNA interactions. Catabolite repression. *Trp* operon – Attenuation, alternative secondary structures of *trp* mRNA. Regulation of gene expression in eukaryotes- Response elements, DNA-binding motifs, steroid receptors, association of methylation and histone acetylation with gene expression.
Unit V	Post transcriptional modifications in eukaryotes- RNA processing-mRNA 5' capping and 3'poly-adenylation, introns and exons, RNA splicing,- spliceosome assembly, alternative splicing, processing of tRNA and rRNA, self-splicing, ribozymes,RNA editing- substitution and insertion/deletion editing, Genome editing-CRISPR- Cas technology Post translational modification of proteins- Proteolytic cleavage, covalent modifications, glycosylation of proteins, disulfide bond formation, Protein sorting – signal peptides, transport of secretory proteins, Golgi and post-golgi sorting, coated vesicles, targeting of mitochondrial, lysosomal and nuclear proteins, Protein degradation-Ubiquitination of proteins, Protein folding-chaperones
Reading List (Print and Online)	1. Molecular Biology Free Online Course by MIT Part 3: RNA Uploaded by edX 2. https://mooc.es/course/molecular-biology/ 3. https://onlinecourses.swayam2.ac.in/cec20_ma13/preview 4. https://learn.genetics.utah.edu/ 5. https://www.cellbio.com/education.html 6. https://lifescienceinteractive.com/category/molecular-biology/

Self-Study	1. Multiple roles of noncoding RNAs (long ncRNA ,siRNA, miRNA) in development and differentiation; implication of ncRNAs in pathologies. 2.mRNA degradation- nonsense-mediated decay.
Recommended Texts	1. Lewin's Genes XII : 12th edition, Krebs JE, Goldstein ES, Kilpatrick ST ;Prentice Hall, Delhi 2. Molecular Biology of the Gene : 6th edition, Watson JD , Baker TA, Bell S, Gann A, Levine M, Losick R; Cold Spring Harbor Laboratory Press, New York 3. Essential Cell Biology :3rd edition, Alberts B, Bray D, Hopkin K, Johnson A, Lewis J, Raff M, Roberts K, Walter P ; Garland Science, New York 4. Molecular Cell Biology : 8th edition , Lodish H, Arnold Berk; W.H.Freeman& Co, New York 5. Karp's Cell and Molecular Biology: Concepts and Experiments, 8th Edition; Wiley, India 6. An Introduction to Genetic Analysis 12th edition,, Griffith A. F, Doebley J, Peichel C, David A, Wassarman DA; Albion Press.W.H.Freeman& Co ,New York

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

Methods of assessment:

Recall (K1) - Simple definitions, MCQ, Recall steps, Concept definitions.

Understand/ Comprehend (K2) - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.

Application (K3) - Suggest idea/concept with examples, Solve problems, Observe, Explain.

Analyse (K4)- Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas

Evaluate (K5) - Longer essay/ Evaluation essay, Critique or justify with pros and cons.

Create (K6)- Check knowledge in specific or offbeat situations, Discussion.

Mapping with Programme Outcomes:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	**S**	**S**	**S**	**L**	**M**	**L**	**S**	**S**	**S**	**S**
CO 2	**S**	**S**	**S**	**M**	**M**	**L**	**M**	**S**	**S**	**S**
CO 3	**S**	**S**	**S**	**L**	**M**	**L**	**M**	**S**	**S**	**S**
CO 4	**S**	**S**	**S**	**M**	**M**	**L**	**S**	**S**	**S**	**S**
CO 5	**S**	**S**	**S**	**S**	**S**	**M**	**M**	**S**	**S**	**S**

S-Strong M-Medium L-Low

Course code 23MBC3C3	CORE PAPER – X	
Title of the Course:	**GENE EDITING CELL AND GENE THERAPY**	
Credits:	**4**	**Hours:4**
Pre-requisites, if any:	To introduce students molecular basis of cell gene therapy; viral and nonviral gene transfer techniques and gene therapy applications in hereditary and acquired diseases.	
Course Objectives	1.To train the student in techniques related to the molecular basis of genetic diseases and to incorporate skills essential for various types ofsequencing. 2.To inculcate practical knowledge on comparing the animal models used to model genetic diseases 3.To introduce and also elaborate knowledge about wide varieties of vectors and their features in addition to their applications and to identify the viral and nonviral gene transfer techniques 4.To educate about the characteristics of cell culture, therapeutic strategies in gene therapy with relevant safety/ethics involved and patents aswell.	
Course Outcomes	After completion of the course, the students should be able to: **CO1.** Ability to read, and evaluate scientific articles within the subjects of immune therapy, gene therapy and cell therapy. (K1, & K2) **CO2.** Toclone gene of their interest for several downstream purposes witharobustcomprehensionaboutwidevarietyofapplicablegene delivery vectors. (K1, K2 &K5) **CO3.** Be able to provide examples of diseases that can be treated with immune therapy, gene therapy and cell therapy. (K2, K3 & K4) **CO4.** To identify knowledge gaps and need for further research within their chosen topic of immune therapy, gene therapy or cell therapy. (K2, K4 & K5) **CO5.**To critically discuss and reflect on ethical and social aspects of using immune, gene or cell therapy.The student will be persuaded to contemplate on upcoming technologies for futuristic benefits. (K2, K5 & K6)	
Unit I	Gene Editing: Basis of gene editing, DNA repair mechanisms, Double strand DNA breaks, Nonhomologous End-Joining (NHEJ), Homology directed repair, Programmable nucleases for gene editing, Meganucleases, Zinc-Finger nucleases, Transcription Activator-Like Effector Nucleases (TALEN), CRISPR-Cas systems, gene editing using CRISPR-Cas, drawbacks and major challenges to present gene editing techniques, gene editing for human disease therapy	

Unit II	Gene and cell therapy: Basics of Gene and cell therapy, types of gene therapy, gene therapy strategies, therapeutic targets for gene therapy, choice of the therapeutic target, administration routes, delivery systems, expression of transgene, persistence of the gene therapy, cell targeting, immunological response to the therapy, ethical and legal issues, concerns about gene and cell therapy
Unit III	Vectors for Gene therapy: Non-viral and viral vectors for gene therapy, Physical methods of gene delivery, Polymer, Lipid and inorganic material based chemical systems for gene delivery, Viral vectors, Lentiviral, Adenoviral, Adeno-associated virus, Herpes Simplex virus, vaccinia, baculoviral vectors for gene delivery, choice of viral vector and oncolytic virus. Gene therapy applications, Gene therapy for cancer, suicide and oncolytic gene therapy.
Unit IV	Stem cells and tissue regeneration: Adult and fetal stem cells, embryonic stem cells, cell reprogramming, induced pluripotent stem cells (iPSC), Chemically induced pluripotent stem cells (CiPSC), reprogramming factors, iPSC derived progenitors 'cells, Organoids, three dimensional (3D) bioprinting.
UnitV	Regulatory and Ethical Considerations of stem cell and Gene Therapy, pluripotent stem cell-based cell replacement therapies. Assessing Human Stem Cell Safety, Use of Genetically Modified Stem Cells in Experimental Gene Therapies.Technological challenges towards development of pluripotent stem cell-based cell replacement therapies.
Reading List (Print and Online)	1. Stem Cell Biology, Daniel Marshak, Richard L. Gardener and David Gottlieb, Cold Spring Harbour Laboratory Press 2. Stem cell biology and gene therapy, Booth C., Cell Biology International, Academic Press 3. Stem Cell and Gene-Based Therapy: Frontiers in Regenerative Medicine, Alexander Battler,
Self-Study	1. Applications of gene editing strategies 2. CART therapy for Cancer
Recommended Texts	1. An Introduction to Human Molecular Genetics (2nd Edition), J.J. Pasternak, 2005 2. An Introduction to Molecular Medicine and Gene Therapy 1st Edition by Thomas F. KresinaUpadhyay, S. K. (Ed.). (2021). 3. Human Molecular Genetics (4th Edition), Tom Strachan & Andrew Read, 2010. 4. Stem Cells Handbook: Stewart Sell, Humana Press; Totowa NJ, USA; Oct. 2003,

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

Methods of assessment:

Recall (K1) - Simple definitions, MCQ, Recall steps, Concept definitions.

Understand/ Comprehend (K2) - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.

Application (K3) - Suggest idea/concept with examples, Observe, Explain.

Analyse (K4)- Finish procedure in stepwise manner, Differentiation between various ideas, Map knowledge

Evaluate (K5) - Longer essay/ Evaluation essay, Critique or justify with pros and cons.

Create (K6)- Check knowledge in specific or offbeat situations, Discussion, Debating, Presentation

Mapping with Programme Outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S	L	M	S	M	M	M	M	M	M
CO 2	S	S	S	S	M	M	M	M	M	S
CO 3	S	M	S	S	M	S	S	S	S	S
CO 4	S	L	M	M	M	M	S	M	M	S
CO 5	S	S	S	S	S	S	S	S	S	S

S-Strong M-Medium L-Low

Course code 23MBC3C4	CORE PAPER – XI	
Title of the Course:	**BIOSTATISTICS & DATA SCIENCE**	
Credits:	**4**	**Hours:4**
Pre-requisites, if any:	**Basic knowledge of Statistics and Computer Applications**	
Course Objectives	1. To summarize the data and to obtain its salient features from the vast mass of original data. 2. To understand the concept of various measures of dispersion. 3. To understand the concepts of sampling and learning test of significance. 4. To understand the concept of various attributes and relate to biological studies. 5. To gain knowledge in SPSS, a software package which gives a perfect graphical representation and appropriate result for the data that has been entered	
Course Outcomes	After completion of the course, the students should be able to: CO1: Concepts of statistical population and sample, variables and attributes. Tabular and graphical representation of data based on variables.(K1,K2,K3) CO2:Conditions for the consistency' and criteria for the independence of data based on attributes. Measures of central tendency, Dispersion, Skewness and Kurtosis.(K1,K2,K3) CO3:Learning different sampling methods and analysing statistical significance.(K1,K2,K3,K4) CO4: Understanding students t test , ANOVA , Chi square test to analyse the significance of various research. (K1,K2,K3,K4) CO5: Learning on data science, algorithm for machine learning, artificial intelligence and big data, their applications in clinical and pharma domain . (K1,K2,K3,K4.K6)	
Unit I	Nature of biological and clinical experiments – Collection of data in experiment- Primary and secondary data. Methods of data collection. Classification and tabulation. Different forms of diagrams and graphs related to biological studies. Measures of Averages- Mean, Median, and mode. Use of these measures in biological studies.	
Unit II	Measures of Dispersion for biological characters – Quartile deviation, Mean deviation, Standard deviation and coefficient of variation. Measures of skewness and kurtosis. Correlation and regression – Rank correlation – Regression equation. Simple problems based on biochemical data.	
Unit III	Basic concepts of sampling- Simple random sample stratified sample and systemic sampling. Sampling distribution and standard error. Test of significance based on large samples. Test for mean, difference of means, proportions and equality of proportions.	
Unit IV	Small sample tests – Students't' test for mean, difference of two way means, tests for correlation and regression coefficients. Chi-square test for goodness of a non independence of attributes. F test for equality of variances. ANOVA-one way and two way. Basic concept related to biological studies	

Unit V	Introduction to Data Science, Definition of data science, importance, and basic applications, Machine Learning Algorithms, Deep Learning, Artificial Neural Networks and their Application, Reinforcement Learning, Natural Language Processing Artificial Intelligence (AI), Data Visualization, Data Analysis, Optimization Techniques, Big Data, Predictive Analysis. Application of AI in medical, health and pharma industries.
Reading List (Print and Online)	1. https://www.ibm.com/docs/en/SSLVMB_28.0.0/pdf/Accessibility.pdf 2. https://pure.tue.nl/ws/portalfiles/portal/19478370/20160419_CO_Mzolo.pdf 3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5453888/ 4. https://home.ubalt.edu/ntsbarsh/excel/excel.htm 5. https://students.shu.ac.uk/lits/it/documents/pdf/analysing_data_using_spss.pdf 6. https://www.ibm.com/support/pages/ibm-spss-statistics-28-documentation
Self-Study	1.Simple problems on probability, theoretical distributions, hypothesis testing 2. Relationship between mean, median and mode pros and cons of the measures of central tendency and deviation
Recommended Texts	1. Zar, J.H. (1984) "Bio Statistical Methods", Prentice Hall, International Edition 2. Sundar Rao P. S.S., Jesudian G. & Richard J. (1987), "An Introduction to Biostatistics", 2nd edition,.Prestographik, Vellore, India,. 3. Warren,J; Gregory,E; Grant,R (2004), "Statistical Methods in Bioinformatics",1st edition,Springer 4. Milton,J.S.(1992),. "Statistical methods in the Biological and Health Sciences", 2nd edition ,Mc Graw Hill, 5. Rosner,B (2005), "Fundamentals of Biostatistics", Duxbury Press 6. Introducing Data Science, Davy Cielen, Anro DB Meysman, Mohamed Ali.

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

Methods of assessment:

Recall (K1) - Simple definitions, MCQ, Recall steps, Concept definitions.
Understand/ Comprehend (K2) - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.
Application (K3) - Suggest idea/concept with examples, Solve problems, Observe, Explain
Analyse (K4) - Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas
Evaluate (K5) - Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6) - Check knowledge in specific or off beat situations, Discussion, Presentations

Mapping with Programme Outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S	S	S	S	M	S	L	S	S	S
CO 2	S	S	S	S	M	S	L	S	S	S
CO 3	S	S	S	S	S	S	M	S	S	S
CO 4	S	S	S	S	S	S	M	S	S	S
CO 5	S	S	S	S	S	S	M	S	S	S

S-Strong M-Medium L-Low

Course code 23MBC3P1	COREPAPER-XII	
Title of the Course:	LABORATORY COURSE ON ENZYMOLOGY , MICROBIOLOGY AND CELL BIOLOGY	
Credits:	4	Hours:8
Pre-requisites	Knowledge on basic principles, Instrumentation of Biochemical techniques and metabolic reactions	
Course Objectives	1. To inculcate skill in students enabling them to apprehend the widerknowledgeaboutprinciplesandtechniquestobeemployedforthe assayofenzymesunderinvestigation. 2. Toinculcatetheknowledgeofisolationandpurificationtechniquesofen zymes using alkalinephosphataseas an example 3. Toperformexperimentstostudythefactors affectingenzymeactivity 4. Toachievetraininginassayofenzymes 5. Toachievetraininginbasicmicrobiologicaltechniques– preparationofculture,sterilization and staining methods. 6. Toperformthebloodgroupingtestandtoprepare bloodsmeartostudydiff erenttypesof blood cells 7. Tolearn moleculartechniqueslikeGelelectrophoresisandBlottingtech niques 8. Tointroduceindustrialvisitsothatstudentsmaybeawareofactualneedo ftheindustry andvarious opportunitiesavailable	
Course Outcomes	**On successful completion of this course, students should be able to:** After completion of the course, the students should be able to: **CO1.**Thestudentwillbeabletoemploytherelevanttechniquesforisolati onand purificationofenzymes and gainskill inkineticstudies which is essential forresearch activity (K1,K2,K4) **CO2.**Student will acquire ability in performing enzymeassay, and explicate the methods that form the basis of enzyme characterization. (K1,K2,K4) **CO3.** Learn the Basic concepts in microbiology and cell biology which will be helpful for interdisciplinary research work. (K1,K3,K4) **CO4.** Students will be trained in separation techniques used in molecular Biology which will be supportive in their futureresearch(K1,K3,K4 &K6) **CO5.** Industrial visits will provide the students with an opportunity to learn practically through interaction, working methods and employment practices. Students will have an exposure to Industrial standard and current work practices(K1,K2,K3,K4 &K6)	
Unit I	Enzymology Alkaline Phosphatase a. Isolation of Alkaline Phophatase from goat kidney. b. Purification of alkaline phosphatase c. Checking the purity using SDS-PAGE d. Determination of optimum pH and temperature of alkaline phosphatase. e. Determination of specific activity and Km of alkaline phosphatase.	

	f. Effect of activators and inhibitors on the activity of alkaline phosphatase. Assay of enzymes a. Salivary Amylase b. Acid Phosphatase
Unit II	Microbiology a. Safety measures and Good Laboratory Practices in microbiology laboratory b. Sterilization,Culture and inoculum preparation c. Staining of bacteria – Gram Staining
Unit III	Physiology & Cell Biology a. Test for blood grouping (Haemagglutination). b. Peripheral Blood smear –Staining and Interpretation
Unit IV	Group Experiments a. Separation of proteins based on molecular weight by SDS PAGE b. Agarose gel electrophoresis of genomic DNA
Unit V	Industrial visit can be organised to students through Academia –Industry collaborative Program
Reading List (Print and Online)	1.https://www.researchgate.net/publication/337146254_Kinetic_studies_with_alkaline_phosphatase 2.https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4846332/ 3.https://www.ijsr.net/archive/v3i8/MDIwMTU0MDk=.pdf 4.https://www.researchgate.net/publication/349318898_ABC_of_Periheral_smear 5.https://ncdc.gov.in/WriteReadData/l892s/File608.pdf 6.https://www.ncbi.nlm.nih.gov/books/NBK562156/
Self-Study	1. Preparation of Buffers and pH measurement 2. Michaelis-Menten equation and Lineweaver Burk plot
Books Recommended	1. David Plummer (2001) An Introduction to Practical Biochemistry (3rd ed) McGraw Hill Education (India) Private Ltd 2. Jayaraman, J (2011), laboratory Manual in Biochemistry, New age publishers 3. Fundamentals of Enzymology; 3rd Edn. Nicholas C. Price and Lewis Stevens, Oxford University Press (2012). 4. Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis; Robert A. Copeland , Wiley-VCH Publishers (2000). 5. Cappuccino JG & Sherman N (2005). Microbiology-A Laboratory Manual, Pearson Education Inc 6. Practical Enzymology, Second Revised Edtion: Hans Bisswanger, Wiley – Blackwell; 2 edition (2011)

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

Methods of assessment:

Recall (K1) - Simple definitions, MCQ, Recall steps, Concept definitions.

Understand/ Comprehend (K2) - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.
Application (K3) - Suggest idea/concept with examples, Solve problems, Observe, Explain.
Analyse (K4)- Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas
Evaluate (K5) - Longer essay/ Evaluation essay, Critique or justify with pros and cons.
Create (K6)- Check knowledge in specific or offbeat situations, Discussion.
Mapping with Programme Outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S	S	S	S	M	S	L	S	M	S
CO 2	S	S	S	S	M	S	L	S	M	S
CO 3	S	S	S	S	M	S	M	S	M	S
CO 4	S	S	S	S	S	S	S	S	S	S
CO 5	S	S	S	S	S	S	S	S	S	S

S-Strong M-Medium L-Low

Course code 23MBC3E1	**ELECTIVE PAPER- IV**	
Title of the Course:	**MOLECULAR BASIS OF DISEASES AND THERAPEUTIC STRATEGIES**	
Credits:	**3**	**Hours:3**
Pre-requisites, if any:	Knowledge of Human Physiology, Metabolism and Clinical Biochemistry	
Course Objectives	1.To understand the concepts of the mechanisms involved in regulation of blood sugar and management of diabetes mellitus 2.To gain in-depth knowledge of the mechanisms of cancer and of tumor metastasis 3.The student will review the basic organization of the central and peripheral nervous system that coordinate the sensory and motor functions of the body. In addition, the student will explore impaired features underlying the major neuropathological complications. 4.To gain knowledge in renal diseases 5.To understand the mechanisms involved in cardiac disorders	
Course Outcomes	**On completion of this course the student will be able to understand** **CO1.**Overall view about the complications of diabetes mellitus and its management. **CO2.**Comprehensive understanding of the concepts of cancer biology and implicating the theoretical concepts for further research **CO3**.Understand and appreciate the pathophysiology of conditions affecting the nervous system. **CO4**.A thorough knowledge of renal and cardiac diseases with emphasis related to mechanistic aspects and therapeutic interventions. **CO5.**A thorough knowledge on the experimental models of non-communicable diseases that will be applied for future research or project dissertation. An in-depth knowledge on development of drugs against non-communicable diseases.	
Unit I	Mechanism of blood sugar regulation in human body. Pathophysiology of Type I and II diabetes, Diabetes – investigation methods for the diagnosis of diabetes. Nutritional care. Complications related to diabetes – Diabetic cardiovascular disease, retinopathy, neuropathy and nephropathy. Cellular and molecular mechanism of development of diabetes- Management of Type I and Type II diabetes, drugs for the treatment of diabetes.	
Unit II	Biology of cancer: Overview of hallmarks of cancer. Tumorigenesis, Tumor progression and mechanism of Metastasis. Proto-oncogene to oncogene. Oncogene- myc and src family. Tumor suppressor gene-Rb and p53 pathway in cancer. Diagnosis- Non-invasive imaging techniques, Tumor diagnosis, Interventional radiology, New imaging technique, Molecular techniques in cancer diagnosis.- treatment of cancer- surgery, radiotherapy, chemotherapy, hormonal treatment, and biological therapy. Introduction to personalized medicine.	
Unit III	Brain- neuronal network- memory- Neurogenerative diseases- Parkinson and Alzheimer Disease- molecular understanding of the neurodegenerative diseases- treatment modalities.	

Unit IV	Acute and chronic renal failure, glomerular diseases– glomerulonephritis, nephritic syndrome, diabetes insipidus, diagnosis of kidney disease.
Unit V	Introduction to cardiovascular diseases, Lipids and lipoproteins in coronary heart disease-cardiac enzymes, Molecular changes during cardiac remodeling – hypertrophy of hearts – heart failure- treatment modalities.
Reading List (Print and Online)	1. The Biochemical basis of disease:2018,**Barr AJ;** Portland Press 2. Biochemical Basis of Diseases 3. https://www.biologydiscussion.com/diseases-2/biochemical-basis-of-diseases/44276
Recommended Texts	1. Wills' Biochemical Basis of Medicine: 2nd edition,Thomas H, Gillham B;Elsevier 2. Molecular Biochemistry of Human Diseases,2021,Feuer G ,de la Iglesia F; CRC Press

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total
10	10	5	75	100

Methods of assessment:
Recall (K1) - Simple definitions, MCQ, Recall steps, Concept definitions
Understand/ Comprehend (K2) - MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3) - Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyse (K4) - Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5) - Longer essay/ Evaluation essay, Critique or justify with pros and cons
Mapping with Programme Outcomes:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	**S**	**S**	**S**	**M**	**M**	**S**	**S**	**S**	**S**	**S**
CO 2	**S**	**M**	**S**	**L**	**M**	**M**	**M**	**M**	**M**	**S**
CO 3	**S**	**S**	**M**	**L**	**S**	**S**	**M**	**M**	**S**	**M**
CO 4	**S**	**M**	**M**	**M**	**M**	**M**	**S**	**S**	**M**	**S**
CO 5	**S**	**S**	**M**	**M**	**S**	**M**	**M**	**M**	**S**	**S**

S-Strong M-Medium L-Low

SEMESTER-IV

Course code 23MBC4C1	**CORE PAPER – XIII**	
Title of the Course:	**PHARMACEUTICAL BIOCHEMISTRY**	
Credits:	**5**	**Hours:6**
Pre-requisites, if any:	The student should have a basic knowledge of drug discovery and development. Student should possess basic knowledge bioinformatics to understand and correlate the drug development process.	
Course Objectives	1. To understand the different types of bioinformatic tools for drug discovery. 2. To get an overview of how different bioinformatic toolsaid in the process of target identification, drug screening and quantitative structure activity relationship. 3. To assimilate the involvement of different metabolic pathways involved in drug metabolism and correlate their involvement in elimination process 4. To understand the biochemical basis of drug action at the target tissue. 5. To understand different phases in drug clinical trials and its assessment.	
Course Outcomes	After completion of the course, the students should be able to: **CO1.**To understand and explain the basic concepts of drug discovery and drug development process. **CO2.**To review the different software and computational tools which aid in the design of drugs and its rationalization. **CO3.**To analyze the different stages of the drug discovery process with the target & hit identification, assays for drug screening and preclinical studies. **CO4.**To understand the various phases of the clinical trails and the method of conduct of clinical trails.	
Unit I	Drug discovery and development, drug target identification and validation, Hit identification, General principles of screening, correlations between various animal models and human situations, Correlation between in-vitro and in-vivo screens; Special emphasis on cell-based assay, biochemical assay, radiological binding assay, Pharmacological assay, In vitro, In vivo & Ex-vivo experiments, lead optimization, preclinical studies.	
Unit II	Bioinformatics approaches for drug development: Identification of potential molecules, chemical compound library preparation, Identification of target in pathogen, Ligand & protein preparation, Molecular docking, Binding free energy estimation, High throughput virtual screening, Docking protocol validation and enrichment analysis, Single point energy calculation, Pharmacokinetics and Pharmacodynamics, ADME & toxicity prediction, Molecular dynamic simulation, Rule of three and five, Lipinsky rule, Pharmacophore development, Quantitative structure activity relationship, 3D-QSAR, Techniques of developing a pharmacophore map covering both ligand based and receptor based approaches.	

Unit III	Drug metabolism & interactions: Drug-receptor interactions, receptor theories and drug action, Xenobiotics, xenobiotics phases (Phase-I, Phase-II and Phase-III), role of cytochrome P450 oxidases and glutathione S-transferases in drug metabolism, factors affecting drug metabolism, Enzymes as a drug target, Kinase inhibitors, ATPase inhibitors, drug protein interaction, DrugDNA interaction. Basic ligand concepts-agonist, antagonist, partial agonist, inverse agonist, efficiency and potency. Forces involved in drug-receptor complexes. Receptor classification – the four super families. Receptor binding assays- measurement of Kd, Bmax and IC_{50}.
Unit IV	Biochemical mode of action of antibiotics- penicillin and chloramphenicol, actions of alkaloids, antiviral and antimalarial substances. Biochemical mechanism of drug resistance- sulphonamides. Drug potency and drug efficacy. General principles of chemotherapy: chemotherapy of parasitic infections, fungal infections, viral diseases. Introduction to immunomodulators and chemotherapy of cancer.
Unit V	Clinical trials (Phase-I, Phase-II, Phase-III and Phase-IV clinical trial). Main features of clinical trials, including methodological and organizational considerations and the principles of trial conduct and reporting. Key designs surrounding design, sample size, delivery and assessment of clinical trials.
Self-Study	1. Examples of pharmaceutical development of a drug 2. Basic pharmacology of drug action and kinetics
Reading List (Print and Online)	1. Textbook of Drug Design. Krogsgaard-Larsen, Liljefors and Madsen (Editors), Taylor and Francis, London UK, 2002. 2. Drug Discovery Handbook S.C. Gad (Editor) Wiley-Interscience Hoboken USA, 2005
Recommended Texts	1. Practical Application of Computer-Aided Drug Design, Ed. Charifson P., Marcel Dekker Inc. 2. 3D QSAR in Drug Design: Theory, Methods and Applications, Ed. Kubinyi H., Ledien 3. Pharmaceutical Profiling in Drug Discovery for Lead Selection, Borchardt RT, Kerns, EH, Lipinski CA, Thakker DR and Wang B, AAPS Press, 2004 4. Drug Discovery and Development; Technology in Transition. HP Rang. Elsevier Ltd 1st edition 2006. 5. Pharmacology in Drug Discovery. T. P. Kenakin. Elsevier, 1st Edition 2012.

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

Methods of assessment:

Recall(K1)-Simpledefinitions,MCQ,Recallsteps,Conceptdefinitions.

Understand/Comprehend(K2)-MCQ,True/False,Shortessays,Concept explanations,Shortsummaryoroverview.

Application(K3)-Suggestidea/conceptwithexamples,Solveproblems,Observe,Explain.

Analyse(K4) – Problem-saving questions,Finish a procedure in many steps,Differentiate between various ideas.
Evaluate(K5)-Longer essay/ Evaluationessay,Critiqueorjustifywithprosandcons
Create(K6) – Check knowledge in specific or offbeat situations.Discussion.
Mapping with Programme Outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S	M	S	M	S	M	M	S	S	S
CO 2	S	S	S	M	M	S	S	S	S	S
CO 3	S	S	S	L	S	M	M	S	S	M
CO 4	S	M	S	L	S	L	M	S	S	M
CO 5	S	S	S	L	S	M	M	S	S	S

S-Strong M-Medium L-Low

Course code 23MBC4C2	CORE PAPER – XIV	
Title of the Course:	**BIOCHEMICAL TOXICOLOGY**	
Credits:	**5**	**Hours:6**
Pre-requisites, if any:	The student should have a basic knowledge of pharmacology of drug action and understanding on their biochemical pathways.	
Course Objectives	1. To understand the detailed study of biochemical basis of drugs and its toxicity, particularly their actions on living systems. 2. To understand the relevance and methods to identify the chemotherapeutic value of drug. 3. To understand the fundamentals of toxicology and dose- response relationships. 4. To understand the toxicological drug testing procedures based on in vitro and animal studies 5. To understandbiochemical pathways of drug toxicity and its manifestation on vital organs.	
Course Outcomes	On completion of this course, the student will be able **CO1:** To appreciate and understand the role of toxicologicalbiomarkers to assess drug toxicities. **CO2:**To conceive the role of disposition of drug in human system and their metabolism and methodologies pertaining to toxicological studies. **CO3:**To understand and evaluate the functions of different organs on drug disposition and associated drug toxicities. **CO4 :**To understand the toxicological response to foreign compounds and their pharmacological, physiological and biochemical effects. **CO5:**To link the mechanism of toxicity and clinical symptoms with underlying physiological disturbances.	
Unit I	Fundamentals of Toxicology and dose-Response Relationships: Introduction Biomarkers Criteria of Toxicity New Technologies Evaluation of Toxicity Interactions; Dose Response; Measurement of Dose-Response; Relationships Linear Dose Response Hormesis; Hazard and Risk Assessment Duration and Frequency of Exposure and Effect	
Unit II	Factors Affecting Toxic Responses: Disposition: Absorption ,Sites of absorption, distribution, Excretion; Metabolism: types of Metabolic change phase I reactions; Phase 2 reactions; control of Metabolism, Toxication vs. Detoxication	
Unit III	Toxicity testing; Test protocol, Genetic toxicity testing & Mutagenesis assay: In vitro test systems: bacterial mutation tests-Reversion test,Ames test, Fluctuation test, and Eukaryotic mutation test. In vivo test system Mammalian mutation test-Host mediated assay and Dominant Lethal test. Biochemical basis of toxicity: Mechanism of toxicity: Disturbance of excitable membrane function, Altered Calcium homeostasis, Covalent binding to cellular macromolecules & genotoxicity, Tissue specific toxicity	

Unit IV	Toxic Responses to Foreign Compounds: Direct Toxic Action: Tissue Lesions; Mechanism and response in cellular toxicity, pharmacological, physiological and Biochemical effects; Developmental Toxicology-Teratogenesis; Immunotoxicity Genetic Toxicity; Chemical Carcinogenesis
Unit V	Biochemical Mechanisms of Toxicity: Tissue Lesions: Liver Necrosis; kidney Damage; Lung Damage, Liver damage, Cardiac damage; Neurotoxicity; Exaggerated and Unwanted pharmacological effects; Physiological effects; Biochemical Effects: Lethal Synthesis and Incorporation, Interaction with specific Protein Receptors; Teratogenesis; Immunotoxicity; multi-Organ Toxicity
Self-Study	• Case studies to review
Reading List (Print and Online)	1. Preclinical Safety Evaluation of Biopharmaceuticals: A Science-Based Approach to Facilitating Clinical Trialsby Joy A. Cavagnaro 2. A Comprehensive Guide to Toxicology in Nonclinical Drug Development 2nd Editionby Ali S. Faqi
Recommended Texts	1.Principles Of Toxicology by: Karen E Stine, Thomas M Brown 2006 Publisher. Crc Press 2. Principles of Biochemical Toxicology by John A. Timbrell Publisher: Informa Healthcare 3. Environmental Toxicology by Sigmund F. Zakrzewski, (2002) Publisher: Oxford University Press, USA

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

Methods of assessment:

Recall(K1)-Simpledefinitions,MCQ,Recallsteps,Conceptdefinitions.

Understand/Comprehend(K2)-MCQ,True/False,Shortessays,Concept explanations,Shortsummaryoroverview.

Application(K3)-Suggestidea/conceptwithexamples,Solveproblems,Observe,Explain.

Analyse(K4) – Problem-saving questions,Finish a procedure in many steps,Differentiate between various ideas.

Evaluate(K5)-Longer essay/ Evaluationessay,Critiqueorjustifywithprosandcons

Create(K6) – Check knowledge in specific or offbeat situations.Discussion.

Mapping with Programme Outcomes:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	**S**	**S**	**S**	**L**	**S**	**L**	**M**	**M**	**M**	**M**
CO 2	**M**	**M**	**S**	**M**	**M**	**L**	**M**	**S**	**S**	**S**
CO 3	**S**	**S**	**S**	**M**	**M**	**L**	**S**	**S**	**M**	**M**
CO 4	**S**	**M**	**S**	**M**	**M**	**M**	**S**	**S**	**M**	**M**
CO 5	**M**	**S**	**S**	**S**	**S**	**M**	**M**	**M**	**S**	**S**

S-Strong M-Medium L-Low

Course code 23MBC4E1	ELECTIVE PAPER V	
Title of the Course:	BIO-SAFETY, LAB SAFETY AND IPR	
Credits:	3	Hours:4
Pre-requisites, if any:	The student should have a basic knowledge of hazards associated with the handling of biological agents and importance of intellectual property from scientific research.	
Course Objectives	1. To assimilate the hazards associated with the handling of biological and chemical agents. 2. To understand how to protect from the hazards by the implementation of various safety measures in biochemical laboratories. 3. To implicate the importance of protecting the scientific intellect by filing patent and understand the various offices for filing and maintaining patents 4. To understand the scope of patenting in biological research. 5. To create an awareness of ethics associated with used of genetically modified organisms/cells and its rationale for use in living organisms.	
Course Outcomes	After completion of the course, the students should be able to: **CO1.**To understand and implement various aspects of biosafety and carry out risk assessment of products in biological research **CO2. U**nderstand the basic concepts of ethics and safety that are essential for different disciplines of science and procedures involved and protection of intellectual property and related rights. **CO3.**To appreciate the intellectual property rights and its implementation of on the invention related to biological research. **CO4.** To understand the statutory bodies that regulate the property rights and its validity in various countries. **CO5.** Critique the ethical concerns associated with modern biotechnology processes and plan accordingly.	
Unit I	Biosafety: Historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; recommended biosafety levels for infectious agents and infected animals; biosafety guidelines - government of India, roles of IBSC, RCGM, GEAC etc. for GMO applications in food and agriculture; environmental release of GMOs; risk assessment; risk management and communication; national regulations and international agreements.	
Unit II	Laboratory safety - Chemical, electrical and fire hazards; handling and manipulating human or animal cells and tissues, toxic, corrosive or mutagenic solvents and reagents; mouth pipetting, and inhalation exposures to infectious aerosols, Safe handling of syringe needles or other contaminated sharps, spills and splashes onto skin and mucous membranes. Health aspects; toxicology, allergenicity, antibiotic resistance. History of biosafety microbiology and molecular biology, Risk assessment, Personal protective equipment, Laboratory facilities and safety equipment, Disinfection, decontamination, and sterilization,	

	Regulatory compliance, Laboratory security and emergency response and administrative controls.
Unit III	Intellectual Property Rights (IPR): Introduction to patents, types of patents, process involved in patenting in India, trademarks, copyright, industrial design, trade secrets, traditional knowledge, geographical indications, history of national and international treaties and conventions on patents, WTO, GATT, WIPO, Budapest Treaty, Patent Cooperation Treaty (PCT) and TRIPS. Patent databases: Searching international databases; analysis and report formation. Indian Patent Act 1970; recent amendments; filing of a patent application; precautions before patentingdisclosure/non-disclosure; procedure for filing a PCT application. The patentability of microorganisms-claims, Characterization and repeatability disposition in the culture collections, legal protection for plants andother higher organisms, new plant varieties by rights, tissue culture protocols
Unit IV	Patent filing and infringement: Patent application- forms and guidelines, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and convention patent applications, International patenting-requirement, financial assistance for patenting-introduction to existing schemes; Publication of patents-gazette of India, status in Europe and US. Research Patenting: Patenting by researchers and scientists-University/organizational rules in India and abroad. Detailed information on patenting biological products, Case studies on patents (basmati rice, turmeric, neem etc.), and patent infringement.
Unit V	Bioethics: Introduction to bioethics, human genome project and its ethical issues, genetic manipulations and their ethical issues, ethical issues in GMOs, foods and crops in developed and developing countries, environmental release of GMOs, ethical issues involved in stem cell research and use, use of animals in research experiments, animal cloning, human cloning and their ethical aspects, testing of drugs on human volunteers.
Self-Study	1. Review of drug patent documents 2. Safety in biological research laboratories
Reading List (Print and Online)	1. V. Shree Krishna, (2007). Bioethics and Biosafety in Biotechnology, New Age International Pvt. Ltd. Publishers. (Unit III, Unit IV and Unit V) 2. Deepa Goel, Shomini Parashar, (2013). IPR, Biosafety and Bioethics, Pearson. (Unit II) 3. R. Ian Freshney, 2016. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, 6th Ed, John Wiley & Blackwell. 4. BAREACT, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007. (Unit I)

Recommended Texts	1. Biosafety in Microbiological and Biomedical Laboratories, (2020) 6th Ed. (https://www.cdc.gov/labs/pdf/SF__19_308133-A_BMBL6_00-BOOK-WEB-final3.pdf) 2. Kankanala C., (2007), Genetic Patent Law & Strategy, 1st Edition, Manupatra Information Solution Pvt. Ltd.,

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

Methods of assessment:

Recall(K1)-Simpledefinitions,MCQ,Recallsteps,Conceptdefinitions.

Understand/Comprehend(K2)-MCQ,True/False,Shortessays,Concept explanations,Shortsummaryoroverview.

Application(K3)-Suggestidea/conceptwithexamples,Solveproblems,Observe,Explain.

Analyse (K4) – Problem-saving questions, Finish a procedure in many steps, Differentiate between various ideas.

Evaluate(K5)-Longer essay/ Evaluationessay,Critiqueorjustifywithprosandcons

Create(K6) – Check knowledge in specific or offbeat situations. Discussion.

Mapping with Programme Outcomes:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	**S**	**S**	**S**	**M**	**S**	**M**	**S**	**S**	**S**	**S**
CO 2	**S**	**S**	**S**	**L**	**M**	**M**	**S**	**S**	**S**	**S**
CO 3	**S**	**M**	**M**	**M**	**S**	**M**	**S**	**S**	**S**	**M**
CO 4	**S**	**M**	**M**	**L**	**S**	**L**	**S**	**S**	**S**	**M**
CO 5	**S**	**S**	**S**	**L**	**S**	**M**	**S**	**S**	**S**	**S**

S-Strong M-Medium L-Low

Course code 23MBC4S1	SEC-3	
Title of the Course:	**DEVELOPMENTAL BIOLOGY**	
Credits:	**2**	**Hours:4**
Pre-requisites, if any:	Comprehensive Knowledge of Cell Biology	
Course Objectives	The candidates undertaking this course will understand the concepts of developmental biology. 1. To understand the background of developmental biology 2. To gain in-depth knowledge of various model organisms 3. To gain insight into aspects of stem cell technology 4. To gain insights into morphogenesis and oranogenesis 5. To acquire in-depth understanding of cell death mechanisms and cell fate decision	
Course Outcomes	**CO1**.Grasp knowledge about the background of developmental biology **CO2**.Gain abundant knowledge about model oraganisms and gametogenesis **CO3**.Gain knowledge about stem cells and their applications in regenerative therapy **CO4**.Good knowledge about organogenesis **CO5**.Learn the basics of cell death mechanisms and cell fate decision .	
Unit I	Overview of Developmental biology: Background of Developmental biology - Principles of developmental biology –Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenicsin analysis of development.	
Unit II	Model organisms Gametogenesis – production of gametes, Formation of zygote, fertilization and early development: molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in plants;cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination. Drosophila Developmental biology- Axis formation, Genes & mutation. *C.elegans*– Vulva formation, Axisformation.	
Unit III	Regeneration Developmental Biology Stem cells – Definition, Classification, Embryonic and adult stem cells, properties, identification, Culture of stem cells, Differentiation and dedifferentiation, Stem cellmarkers, techniques and their applications in modern clinical sciences. Three- dimensional culture and transplantation of engineered cells. Tissue engineering - skin, bone and neuronaltissues.	

Unit IV	Morphogenesis &Organogenesis:Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila, amphibia and chick; organogenesis – vulva formation in Caenorhabditis elegans, eye lens formation, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.
Unit V	Cellular senescence and Cell fate decision Cellular senescence – concepts & Frizzled receptor in Development and disease. Diabetes and developmental biology, Cell death pathways in developments. Markers of important diseases.
Reading List (Print and Online)	Developmental Biology – Gilbert Scott http://bgc.org.in/pdf/study-material/developmental-biology-7th-ed-sf-gilbert.pdf
Recommended Texts	Developmental biology: VIII edition, **Gilbert, S**F; Sinauer Associates, Inc

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

Methods of assessment:

Recall(K1)-Simpledefinitions,MCQ,Recallsteps,Conceptdefinitions.

Understand/Comprehend(K2)-MCQ,True/False,Shortessays,Concept explanations,Shortsummaryoroverview.

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Evaluate(K5)-Longer essay/ Evaluationessay,Critiqueorjustifywithprosandcons

Create(K6) – Check knowledge in specific or offbeat situations.Discussion.

Mapping with Programme Outcomes:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	**S**	**M**	**M**	**S**	**S**	**M**	**L**	**S**	**S**	**M**
CO 2	**M**	**M**	**M**	**M**	**M**	**S**	**M**	**S**	**M**	**M**
CO 3	**M**	**M**	**L**	**M**	**M**	**S**	**L**	**S**	**L**	**L**
CO 4	**S**	**M**	**L**	**S**	**S**	**M**	**S**	**S**	**M**	**M**
CO 5	**S**	**S**	**M**	**S**	**L**	**M**	**M**	**S**	**M**	**M**

S-Strong M-Medium L-Low