APPENDIX – CL

MADURAI KAMARAJ UNIVERISTY

(*University with Potential for Excellence*)

Revised Syllabus for

M.Sc. Biochemistry (Semester)

CHOICE BASED CREDIT SYSTEM

(With effect from the academic year 2023-2024 onwards)

1. Introduction of the Programme

The Master of Science in Biochemistry is a full- time programme spread over 2 years and is divided into 4 semesters. The programme of study shall consist of 12 core papers which are compulsory, 4 elective papers, 3 practical, 4 skill based courses and one project. Each of these carry100 marks. It has been developed to provide students the opportunity to be trained in recent development in Biochemistry. The course is designed to impart the students a vigorous training in Biochemistry both in theory and experiments. Our approach is a comprehensive one. It is believed that teaching students both how to ask and address questions. This Programme has been designed to expose students' knowledge in Biochemistry to contemporary national and international problems. At the end of the course, students are expected to have state- of- the- art quantitative skills valued both in academia and in the corporate world. During the course time, one gets as in-depth knowledge about core subjects like Advances in Biochemistry, Clinical Biochemistry, Molecular Biology and Microbiology.

2. Eligibility for Admission

B.Sc., degree from UGC recognized Universities with Biochemistry/ Botany, Zoology, Biology, Chemistry, Microbiology, Agriculture, Nutrition & Dietetics and Biotechnology as major subjects or an examination accepted as equivalent there to by the syndicate are eligible for seeking admission to M.Sc Biochemistry. Candidates belonging to general category should have secured at least 55% of marks, OBC candidates must have secured 50% marks and SC/ST /Candidates with disability must have passed in the qualifying examination for admission , as prescribed by Government of Tamil Nadu Madurai Kamaraj University.

2.1. Duration of the Programme : 2 Years

2.2. Medium of Instructions : English

3. Objectives of the Programme

- To offer the knowledge, understanding and skills to PG students.
- To offer a balance between Theoretical and Experimental –Biochemistry.
- To improve the employability of the students
- To develop core competencies on critical thinking skills, hypothesizing and solving problems.

4. Outcome of the Programme

- It serves as a basis to build a purely academic profile for further studies and research in Biochemistry such as M.Phil and Ph.D.
- On successful completion of this course, one can apply for the UGC-NET or JRF exam. The success in these exams makes teaching or research as good options.
- The degree holders can opt for further higher studies and career in various specializations of Biochemistry such as Medical Biochemistry, Molecular Diagnostics, Biosensors, Microbial Biochemistry, Plant Biochemistry and Environmental Biochemistry.

5. Core Subject Papers

Core Subject papers shall consists of 12 papers as listed below.

1. Basics of Biochemistry
2. Biochemical and Molecular Biology Techniques
3. Physiology and Cell Biology
4. Enzymology
5. Cellular Metabolism
6. Clinical Biochemistry
7. Industrial Microbiology
8. Molecular Biology
9. Gene Editing, Cell and Gene Therapy
10. Pharmaceutical Biochemistry
11. Biochemical Toxicology
12. Developmental Biology

6. **Subject Elective Papers**

Elective papers shall consist of4papers as listed below.

1. Microbiology and Immunology
2. Energy and Drug Metabolism
3. Biostatistics and Data Science
4. Biosafety, Lab Safety and IPR

8. Unitization

Each subject Paper consists of five units. One unit (Preferably the 5th unit) will be handled by the students as a part of peer team teaching/learning process.

9. Pattern of Semester Examination

Two-year M. Sc., Biochemistry degree shall be having examinations of 12 core papers, 4 subject- Elective papers and four Skill based courses to be conducted in four semesters. Each semester shall consist of five examinations for five subjects. First and third semester examinations shall be conducted in the month of November. The second and fourth semester examinations shall be held in the month of April. Each paper shall carry 100 marks of which 25 marks for internal assessment and 75 marks for external examinations for all the theory papers. For practical, 40 marks for internal and 60 marks for external.

10. Scheme of Internal Assessment

The components of Internal Assessment marks shall be as follows, for theory.

Test	: 10 Marks (Average of the best two tests)
Assignment	: 5 Marks
Seminar/ Group Discussion	: 5 Marks
Peer Team Teaching	: 5 Marks
Total	**: 25 Marks**

For practical, 40 marks is for internal.

11. External Examinations

External examination for each Theory paper shall be conducted for 75 marks. Section A: 10 Multiple choice questions (One question from each unit) (10 × 1= 10 marks)
Section B: 5 either/ or type questions (One question from each unit) (5 × 7 = 35 marks)
Section C: 3 out of 5 questions. This may include 2 problems. (3 ×10=30 marks)
Total : 75 Marks.

12. Question paper pattern

Internal Examination of each paper shall be for 10 marks having the following question pattern.

Section A: 5 Objective type questions (6 × 1= 6 marks)
Section B: 2 questions in either or type (2 × 7= 14 marks)
Section C: One out of 2 questions (1 ×10=10 marks)
Total : 25 Marks

External examination of each paper shall be for 75 marks having the following question paper pattern, for theory papers.

Section A: 10 Objective type questions (2 question from each unit) (10× 1= 10 marks)
Section B: 5 questions in either or type (1 question from each unit) (5 × 7 = 35 marks)
Section C: 3 out of 5 questions (1 question from each unit) (3 ×10=30 marks)
(This may include 2 problems)

Total : 75 Marks.

13. Scheme of Evaluation

Students shall be evaluated on the basis of internal tests, seminar, and assignment, peer- teaching and external examinations. Question paper setters shall be requested to prepare scheme of valuation for all the papers.

14. Passing Minimum

Total Passing Minimum : 50 Marks out of 100 Marks
Internal Assessment : No minimum pass marks out of 25 Marks
External Assessment : 34 Marks out of 75 Marks

14.1. Classification

S.No.	Range of CGPA	Class
1.	40 & above but below 50	III
2.	50 & above but below 60	II
3.	60 & above	I

15. Model Question paper

Maximum Time: 3 hrs Maximum Marks: 75

Section A
Answer All Questions

All multiple choice Questions (10 × 1= 10 Marks)
Two Questions from each Unit
(Questions are numbered from 1 to 10)

Section B
Answer All Questions

(Either/ or type: either (a) or (b)) (5 × 7= 35 Marks)
One question from each Unit
(Questions are numbered from 11 to 15)

Section C
Answer any three Questions

One question from each Unit (3 × 10= 30 Marks)
(Questions are numbered from 16 to 20)

16. Teaching Methodology

Methodology shall consist of stimulation of students' interest, presentation of teaching material, team formation and activities' determination, conduction of activities and discussion and assessment. For the sake of simplicity and easy understand, the methods like problem solving, discussion, lab demonstration and lecture method shall be adopted. The use of ICT shall be co- opted for the visual presentation of the lessons. One unit (mostly 5^{th} unit will be handled by the students).

17. Text Books

The list of text books is given at the end of syllabus of each paper.

18. Reference Books

The list of reference books is given at the end of syllabus

19. Retotaling and Revaluation Provision

Students shall be provided the facility of applying for retotaling the marks within 15 days after the publication of results on payment of a minimum fee fixed by the University and they shall be allowed to apply for revaluation of their papers within 15 days after the publication of results on payment of a fee to be fixed by the University.

20. Transitory Provision (2+2)

Syllabus revision shall be done once in 2 years and afterwards 2 years shall be under transitory provision.

21. Subjects and paper related websites

The related websites for each paper shall be provided at the end of the syllabus wherever necessary.

MASTER OF BIOCHEMISTRY

PROGRAMME CONTENT

M.Sc. Biochemistry -SEMESTER I

S.No.	Components		Title of the Course	Course Code	Hours Per Week	Credits	Exam. Hours	Marks		
								Int.	Ext.	Total
1.	**Part A**	Core Course -I	Basics of Biochemistry		5	4	3	25	75	100
2		Core Course -II	Biochemical and Molecular Biology Techniques		5	4	3	25	75	100
3.		Core Course -III	Physiology and Cell Biology		5	4	3	25	75	100
4.		Core Practical- I	Laboratory Course on Biomolecules and Biochemical Techniques		6	4	3	40	60	100
5.		**Elective-I** (Generic/ Discipline Centric)	Microbiology and Immunology		5	3	3	25	75	100
6.	**Part B**	AEC – Soft Skill-1			2	2				100
7.		SEC- 1	Fundamentals of Forensic Science		2	2				100
Total					**30**	**22**				**700**

M.Sc. Biochemistry -SEMESTER II

S.No.	Components		Title of the Course	Course Code	Hours Per Week	Credits	Exam. Hours	Marks		
								Int.	Ext.	Total
1.	**Part A**	Core Course -IV	Enzymology		5	4	3	25	75	100
2		Core Course -V	Cellular Metabolism		5	4	3	25	75	100
3.		Core Course -VI	Clinical Biochemistry		5	3	3	25	75	100
4.		**Core practical-II**	Lab Course in Enzymology, Microbiology and Cell Biology		6	4	3	40	60	100
5.		**Elective-II** (Generic/ Discipline Centric)	Energy and Drug Metabolism		5	3	3	25	75	100
6.	**Part B**	AEC – Soft Skill-2			2	2				100
7.		SEC- 2	Internship (Clinical Biochemistry)		2	2				100
Total					**30**	**22**				**700**

M.Sc. Biochemistry -SEMESTER III

S.No.	Components		Title of the Course	Course Code	Hours Per Week	Credits	Exam. Hours	Marks		
								Int.	Ext.	Total
1.	**Part A**	Core Course -I	Industrial Microbiology		5	4	3	25	75	100
2		Core Course -II	Molecular Biology		5	4	3	25	75	100
3.		Core Course -III	Gene Editing, Cell and Gene Therapy		5	4	3	25	75	100
4.		Core Practical-III	Laboratory Course on Clinical Biochemistry		6	4	3	40	60	100
5.		**Elective-I** (Generic/ Discipline Centric)	Biostatistics and Data Science		5	3	3	25	75	100
6.	**Part B**	AEC – 3	Industrial visit-Bitech Companies		2	2				100
7.		SEC- 3	Term Paper and Seminar Presentation		2	2				100
			Internship/Industrial Activity		-	2				
Total					**30**	**24**				**700**

M.Sc. Biochemistry -SEMESTER IV

S.No.	Components		Title of the Course	Course Code	Hours Per Week	Credits	Exam. Hours	Marks		
								Int.	Ext.	Total
1.	**Part A**	Core Course -IV	Pharmaceutical Biochemistry		5	4	3	25	75	100
2		Core Course -V	Biochemical Toxicology		5	4	3	25	75	100
3.		Core Course -V	Developmental Biology		5	4	3	25	75	100
4.		**Elective-IV**	Biosafety, Lab safety and IPR		5	3	3	25	75	100
5.		**Project with Viva-Voce**			6	3	3	25	75	100
6.	**Part B**	AEC – 4	Industrial visit-Pharma or Food processing		2	2				100
7.		SEC- 4	Professional Competency Skill		2	2				100
			Extension Activity		-	1				
Total					**30**	**23**				**700**

Course	COREPAPERI
TitleoftheCourse:	BASICS OF BIOCHEMISTRY
Credits:	4
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 chemicalstructureandfunctionsofcarbohydrates.(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, keratansulphate,. 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.
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.
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, RosemannRossmannfold , 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.
IV	Membrane Proteins - Types and their significance. Cytoskeleton proteins - actin , tubulin , intermediate filaments . Biological role of cytoskeletal proteins. Membrane structure-fluid mosaic model
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. LubertStryer(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	Grade
10	10	5	75	100	

Methodsofassessment:

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**

S: Strong = 3, M: Medium – 2, L: Low = 1

S- Strong M-Medium L-Low

Course	COREPAPERII
Title of the Course:	**BIOCHEMICAL AND MOLECULAR BIOLOGY TECHNIQUES**
Credits:	**4**
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	
I	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.
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.
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.
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
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%20techiniques%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 of Biochemistry and Molecular Biology (7th ed) Cambridge University Press 2.David Sheehan (2009), Physical Biochemistry: Principles and Applications (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-S	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

S: Strong = 3, M: Medium – 2, L: Low = 1

Course	**CORE PAPER -III**
Title of the Course:	**PHYSIOLOGY AND CELL BIOLOGY**
Credits:	**4**
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	

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.
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.
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.
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.
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.
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. LeschNyhan syndrome , oroticaciduria 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 = 3, M: Medium – 2, L: Low = 1

Course	**CORE ELECTIVE PAPER -I**

Title of the Course:	**MICROBIOLOGY & IMMUNOLOGY**
Credits:	**3**
Pre-requisites, if any:	The student should possess basic knowledge about microorganisms,types andtheirgeneralcharacteristics.Thestudentsarealsoexpectedtopossess basic understanding about the process of infection, immunological defence and pathological outcomes, if any.
Course Objectives	1. To appreciate the classification of microorganisms based on their structure, size and shape with an insight into the ancient scriptures aboutmicrobes. 2. To understand the role of microorganisms in environment and also to learn the cultureconditions. 3. To recognize the possible contamination of foods by microorganisms, to learn about counteracting preservative measures and to know about probiotic nature ofmicroorganisms. 4. To gain knowledge on pathogenic mediation by microorganisms and preventive measures as well. 5. To comprehend the features of antimicrobial agents, their mechanism of action along with the side effects and also toexplore natural remedial measures againstmicrobes. 6. 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	
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.
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.
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)
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).
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 (5thed), McGraw Hill Education (India) Private Limited 3.Willey J and Sherwood L (2011) ,Prescott's Microbiology (8thed) McGraw Hill Education (India) 4.Ananthanarayanan , Paniker and ArtiKapil (2013) Textbook of Microbiology (9thed) 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,(26thed) 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	**COREPAPERIV**
TitleoftheCourse:	**ENZYMOLOGY**

Credits:	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	
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
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
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-Mentenequation . 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. Michaelis -Menten equation in the presence of competitive, uncompetitive and non-competitive inhibitors. Graphical analysis - Diagnostic plots for the determination of inhibition type. Therapeutic use of enzyme inhibitors-Aspirin, statins (irreversible inhibitors), Methotrexate (competitive inhibitor), Etoposide (non-competitive inhibitor), camptothecin (uncompetitive inhibitor). Demonstration :Using Microsoft Excel to Plot and Analyze Kinetic Data
IV	Enzyme kinetics II: Allosteric enzymes: Cooperativity, MWC and KNF models of allosteric enzymes, Sigmoidal kinetics taking ATCase as an example. Regulation of amount and catalytic activity by - extracellular signal, transcription, stability of mRNA, rate of translation and degradation, compartmentation, pH, temperature, substrate concentration, allosteric effectors, covalent modification. Regulation of glycogen synthase and glycogen phosphorylase. 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.
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	**COREPAPERV**
TitleoftheCourse:	**CELLULAR METABOLISM**
Credits:	**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:** After completion of the course, the 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	
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.

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.
III	Metabolism of nucleotides- *De novo* synthesis and salvage pathways of purine and pyrimidine nucleotides. Regulation and inhibitors of nucleotide biosynthesis. Role of ribonucleotidereductase and its regulation. Degradation of purine and pyrimidine nucleotides.
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 hydroxyproline, α-ketoglutarate from histidine and proline, succinate from methionine, threonine, valine and isoleucine, Oxaloacetate from aspartate, glycine and serine.
V	Biosynthesis and degradation of heme. Jaundice-classification, pathology and Differential diagnosis Oxidation and reduction of inorganic sulphur compounds by microbes and plants. Sulphotransferases and their biological role-rhodanases, sulphatases , 3-mercapto pyruvate sulphurtransferases. 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 I	**CORE PAPER – VI**
Title of the Course:	**CLINICAL BIOCHEMISTRY**
Credits:	**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 diagnosisleading 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	

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
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
III	**Diagnostic Enzymology:** Clinically Important Enzymes and Isoezyme as diagnostic markers: Clinical significance of AST, ALT, ALP, ACP, CK, γ-GT, amylase, pseudocholinesteraseand 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
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)

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. **Electrolyte disorder :** calcium: hypercalcemia and hypocalcemia; Calcium homoestasis in Blood;phosphate: hyperphosphatemia or hypophosphatemia; Clinical significance: Potassium: hyperkalaemia and hypokalaemia, Sodium: hypernatremia and hyponatremia; Chloride: hyperchloremia, hyporchloremia **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 laboratoryinvestigations 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 RanaShinde (2012).Textbook of Medical Biochemistry (8th ed), Jaypee Brothers Medical Publishers. 6. Clinical Case Discussion In Biochemistry A Book On Early Clinical Exposure (ECE), PoonamAgrawal , 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.

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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	**COREPAPERVII**
TitleoftheCourse:	**LABORATORY COURSE ON BIOMOLECULES AND BIOCHEMICAL TECHNIQUES**
Credits:	**4**
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.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 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:** After completion of the course, the 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	
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
II	UV absorption 1. Denaturation of DNA and absorption studies at 260nm. 2. Denaturation of Protein and absorption studies at 280nm.
III	Colorimetric estimations 1. Estimation of Pyruvate 2. Estimation of tryptophan.
IV	Estimation of minerals 1. Estimation of calcium 2. Estimation of iron

V	Plant Biochemistry 1.Qualitative analysis Phytochemical screening 2.Estimation of Flavonoids -Quantitative analysis
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

Course	**COREPAPER-VIII**
TitleoftheCourse:	**LAB COURSE IN ENZYMOLOGY , MICROBIOLOGY AND CELL BIOLOGY**
Credits:	**4**
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. Toperformthebloodgroupingtestandtoprepareбloodsmeartostudydiff erenttypesof blood cells 7. Tolearn molecularbiologytechniqueslikeGelelectrophoresisandBlottingtech 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)
Units	
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

II	Microbiology a. Safety measures and Good Laboratory Practices in microbiology laboratory b. Sterilization,Culture and inoculum preparation c. Staining of bacteria – Gram Staining
III	Physiology & Cell Biology a. Test for blood grouping (Haemagglutination). b. Peripheral Blood smear –Staining and Interpretation
IV	Group Experiments a. Separation of proteins based on molecular weight by SDS PAGE b. Agarose gel electrophoresis of genomic DNA
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	CORE ELECTIVE PAPER II
TitleoftheCourse:	ENERGY AND DRUG METABOLISM
Credits:	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	
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.
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

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
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
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 $\triangle$ 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	**EXTRA DISCIPLINARY PAPER-I**
Title of the Course:	**NUTRITIONAL BIOCHEMISTRY**
Credits:	**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	
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.
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.
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.
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)
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/ 5. 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)-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**	**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	**CORE PAPER IX**
Title of the Course:	**INDUSTRIAL MICROBIOLOGY**
Credits:	**4**
Pre-requisites, if any:	Basic Knowledge of Microbiology and microbial techniques used in the industries.
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.
Units	
I	Structure of bacteria, fungi and viruses and their classifications. Types and characteristics of microorganisms used in Industrial processes (a) Food Industry (b) Chemical Industry (c) Pharmaceutical Industry
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, Anti-foaming devices.
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.
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.

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 pharmaceutical industries • Upstream and Downstream processes in Biopharma industries.
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)
Reading List (Print and Online)	Industrial biotechnology: https://nptel.ac.in/courses/102/105/102105058/ Bioreactors: https://nptel.ac.in/courses/102/106/102106053/ Food Microbiology: https://nptel.ac.in/courses/126/103/126103017/ Agriculture Microbiology: 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 BookCompany. 4. Text book of Microbiology:11th edition, **Ananthanarayanan R and Paniker CKJ;** Universities Press (India) Pvt.Ltd. 5. FoodMicrobiology, 3rd edition, **Frazier WC and WesthoffDC;**TataMcGrawHill Publishing Company Ltd, NewDelhi 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	CORE PAPER –X
Title of the Course:	MOLECULAR BIOLOGY
Credits:	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)
Units	

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.
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.
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.
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.
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	CORE PAPER – XI
Title of the Course:	GENE EDITING, CELL AND GENE THERAPY
Credits:	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)
Units	
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
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
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.
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.
V	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	**CORE ELECTIVE PAPER –III**
Title of the Course:	**BIOSTATISTICS& DATA SCIENCE**
Credits:	**3**
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 vastmass 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)
	Units
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.

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.
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.
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
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. SundarRao 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 ,McGraw 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	**EXTRA DISCIPLINARY PAPER- II**
Title of the Course:	**MOLECULAR BASIS OF DISEASES AND THERAPEUTIC STRATEGIES**
Credits:	**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.
Units	
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.
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.
III	Brain- neuronal network- memory- Neurogenerative diseases- Parkinson and Alzheimer Disease- molecular understanding of the neurodegenerative diseases- treatment modalities.
IV	Acute and chronic renal failure, glomerular diseases– glomerulonephritis, nephritic syndrome, diabetes insipidus, diagnosis of kidney disease.
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, GillhamB;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

Course I	**CORE PAPER – XII**
Title of the Course:	**PHARMACEUTICAL BIOCHEMISTRY**
Credits:	**4**
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 tools aid 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 trials and the method of conduct of clinical trials.
Units	
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.
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.
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}.

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.
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 I	**CORE PAPER – XIII**
Title of the Course:	**BIOCHEMICAL TOXICOLOGY**
Credits:	**4**
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 understand biochemical 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 toxicological biomarkers 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.
Units	
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
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
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
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
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	CORE PAPER – XIV
Title of the Course:	LABORATORY COURSE ON CLINICAL BIOCHEMISTRY
Credits:	4
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	
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
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.
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
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.
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 KawadujiJambhulkar, 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 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**	**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

BIOTECHNOLOGY FOR BIOCHEMISTRY

Course	**CORE PAPER – XV**
Title of the Course:	**BIOTECHNOLOGY FOR BIOCHEMISTRY**
Credits:	**4**
Aim	To impart knowledge on the principles and applications of biotechnology in the field of biochemistry
Course Objectives	1. To understand the fundamental principles and concepts of biotechnology and their applications in biochemistry. 2. To explore various biotechnological techniques and tools used in research and industry. 3. To understand the applications of biotechnology in agriculture, food and beverage, pharmaceuticals, and environmental biotechnology. 4. To develop critical thinking skills in evaluating the ethical, social, and environmental implications of biotechnology 5. To enhance practical skills through hands-on laboratory exercises and case studies.
Units	
I	**Fundamentals of Biotechnology**: Definition, historical development, and scope of biotechnology. Biotechnological tools and techniques: DNA cloning, PCR, gene expression analysis, protein purification, etc. Applications of biotechnology in biochemistry research and industry
II	**Recombinant DNA Technology**: DNA isolation, manipulation, and cloning techniques Construction of recombinant DNA molecules Gene expression and protein production in recombinant systems Genetically modified organisms (GMOs) and their applications

III	**Protein Engineering and Biopharmaceuticals**: Protein structure and function, Protein engineering techniques: site-directed mutagenesis, protein folding, etc. Production of recombinant proteins for therapeutic and industrial purposes Applications of biopharmaceuticals in medicine and biochemistry
IV	**Genome Engineering:** CRISPR-Cas9 and other gene editing technologies Applications of gene editing in research and biotechnology Ethical and social implications of gene editing
V	**Biotechnology in Agriculture , Food Industry and Environment** Plant genetic modification, biofertilizers, biopesticides, etc. Applications of biotechnology in food and beverage production, including fermentation, enzyme technology. Waste treatment and management using biotechnological approaches Biogas production, bioleaching, and other environmental biotechnology applications
Self-Study	1. Fundamentals of Biotechnology 2. Applications of biotechnology in different fields
Reading List (Print and Online)	1. Synthetic Biology: A Primer by Paul S. Freemont and Richard I. Kitney (2019) 2. Molecular Biotechnology: Principles and Applications of Recombinant DNA" by Bernard R. Glick and Jack J. Pasternak 3. Biotechnology for Beginners by ReinhardRenneberg and Viola Berkling (2021)
Recommended Texts	1. "Plant Biotechnology: The Genetic Manipulation of Plants" by Adrian Slater, Nigel W. Scott, and Mark R. Fowler 2. "Biotechnology and Genetic Engineering" by Richard C. Flavell 3. Industrial Biotechnology: Sustainable Production and Bioresource Utilization" by ChristophWittmann and James C. Liao 4. Biotechnology and Biopharmaceuticals: Transforming Proteins and Genes into Drugs by Rodney J. Y. Ho and Milo Gibaldi (2019)

Course	**ELECTIVE PAPER IV**
Title of the Course:	**BIOSAFETY, LAB SAFETY AND IPR**
Credits:	**3**

Pre-requisites, if any:	The student should have a basic knowledge of hazards associated with the handling of biological agents. **Intellectual Property Rights (IPR) can help to protect and manage their research findings and navigate ethical considerations at global scenario.**
Course Objectives	6. To assimilate the hazards associated with the handling of biological and chemical agents. 7. To understand how to protect from the hazards by the implementation of various safety measures in biochemical laboratories. 8. To implicate the importance of protecting the scientific intellect by filing patent and understand the different agencies and organizations for filing and maintaining patents 9. To understand the scope of patenting in biological research. To create an awareness of ethics associated with used of genetically modified organisms/cells and its rationale for use in living organisms.
Units	
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.
II	**Laboratory safety** - Chemical, electrical and fire hazards; handling and manipulating human or animal cells and tissues. Handling of 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, allergen city, antibiotic resistance. History of biosafety in 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.
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 patenting disclosure/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 and other higher organisms, new plant varieties by rights, tissue culture protocols
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.
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	3. Review of drug patent documents 4. Safety in biological research laboratories
Reading List (Print and Online)	4. V. Shree Krishna, (2007). Bioethics and Biosafety in Biotechnology, New Age International Pvt. Ltd. Publishers. (Unit III, Unit IV and Unit V) 5. DeepaGoel, ShominiParashar, (2013). IPR, Biosafety and Bioethics, Pearson. (Unit II) 6. R. Ian Freshney, 2016. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, 6th Ed, John Wiley & Blackwell. 7. BAREACT, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007. (Unit I)

Recommended Texts	5. 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) 6. Kankanala C., (2007), Genetic Patent Law & Strategy, 1st Edition, Manupatra Information Solution Pvt. Ltd.,
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.

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 I	**ELECTIVE PAPER V**
Title of the Course:	**DEVELOPMENTAL BIOLOGY**
Credits:	**3**
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 oranogensesis 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 .

Units	
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.
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.
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.
IV	Morphogenesis &Organogenesis:Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila, amphibia and chick; organogenesis – vulva formation in Caenorhabditiselegans, 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.
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.

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**	**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

Semester I	**FUNDAMENTALS OF FORENSIC SCIENCE**	Hours/Week: 2	
SEC-I		Credits: 2	
Course Code		Internal 40	External 60

On successful completion of the course, the students will be able to

CO1: understand knowledge about the basics of forensic science

CO2: explain the crime scene management, forensic analysis of blood, chemicals, explosives and fingerprints

CO3: apply the knowledge on forensic Science in crime detection

CO4: illustrate the techniques involved in crime scene management and offender identification

CO5:analyze the evidences from the crime scene and give possible suggestions to the judicial

Unit – I

Forensic science: Definitions, History and Development. Crime scene management and investigation; collection, preservation, packaging and forwarding of physical and trace evidence for analysis.

Unit – II

Fresh blood – grouping and typing of fresh blood samples.Analysis of stains of blood and allied body fluids for their groups.Disputed paternity and maternity problems – DNA extraction and profiling techniques.

Unit – III

Analysis of illicit liquor including methyl and ethyl alcohol. Analysis of chemicals in trap cases (Petroleum product, Chemical examination of insecticides, pesticides and psychotropic drugs – Sedatives, opiates). Detection of poisons from viscera, tissues and body fluids.

Unit – IV

Forensic examination and identification of cartridges, bullets, fire arms, bombs and explosives. Tool marks – meaning, type and examination. Photography - types application in criminal investigations and forensic evidence examination.

Unit – V

History, classification, search, lifting and examination of fingerprints.Medicolegal aspects of wounds, Post-mortem examination and PM changes, asphyxia death,sexual offences, infanticide. Forensic psychiatry and lye detection

Text Books

1. Text book of Forensic Medicine and Toxicology; Fifth Edition by KrishanVij; 2011; Elsevier Publications

2. Blood stain pattern analysis: Third Edition by Tom Bevel and Ross M Gardiner.2008: CRC press.

3. Text Book of Medical Jurisprudence; Sixth Edition by RaiBahadurJaising; Butterworth and Co press.

Reference Books

1. CrimeScenePhotographybyEdwardM.Robinson: Second Edition: Elsevier Publication 2010.

2. Criminal Law and Justice by Noel Cross: Sage Publications 2010.

3. Drugs of Abuse by Raphel C. Wong; Humana press 2010.

4. Forensic Criminology by Wein A Patherick and Brent E. Turvey, 2010.

Course Code **23PBCS11**	PO1		PO2	PO3		PO4	PO5	PO6	PO7	PO8
	PSO 1a	**PSO** 1b	**PSO** 2	**PSO** 3a	**PSO** 3b	**PSO** 4	**PSO** 5	**PSO** 6	**PSO** 7	**PSO** 8
CO1	S	S	M	M	S	S	S	S	L	L
CO2	S	S	M	M	S	S	S	S	L	M
CO3	S	M	M	M	S	S	S	S	L	M
CO4	S	S	M	M	S	S	S	S	M	M
CO5	S	S	M	M	S	S	S	M	M	M