

APPENDIX – 22(R&S)
UNIVERSITY OF MADRAS

Programme:	M.Sc. BIOCHEMISTRY CBCS(w.e.f.2022-2023)
Programme Code:	LIFC
Duration:	2 years
Programme Outcomes:	<p>PO1. To make students understand the importance of biochemistry as a subject that deals with life processes, as well as the concepts, theories and experimental approaches followed in biochemistry, in order to pursue a research career, either in an industry or academic setting.</p> <p>PO2. To develop analytical and problem-solving skills</p> <p>PO3. To create an awareness among the students on the interconnection between the interdisciplinary areas of biochemistry.</p> <p>PO4. To give the necessary practical skills required for biochemical techniques and analysis.</p> <p>PO5. To develop a communication and writing skills in students.</p> <p>PO6. To develop leadership and teamwork skills</p> <p>PO7. To emphasize the importance of good academic and work ethics and their social implications.</p> <p>PO8. To emphasize the importance of continuous learning and to promote lifelong learning and career development.</p> <p>PO9. To teach students how to retrieve information from a variety of sources, including libraries, databases and the internet.</p> <p>PO10. To teach students to identify, design and execute a research problem, analyze and interpret data and learn time and resource management.</p>

<p>Programme Specific Outcomes:</p>	<p>Programme Specific Outcomes (PSO)</p> <p>On successful completion of this course, students should be able to:</p> <p>PSO1. Understand the principles and methods of various techniques in Biochemistry, Immunology, Microbiology, Enzyme kinetics and Molecular Cell Biology. Based on their understanding, the students may would be able to design and execute experiments during their final semester project, and further research programs.</p> <p>PSO2. Insight on the structure-function relationship of biomolecules, their synthesis and breakdown, the regulation of these pathways, and their importance in terms of clinical correlation. Students will also acquire knowledge of the principles of nutritional biochemistry and also understand diseases and their prevention.</p> <p>PSO3. To understand the concepts of cellular signal transduction pathways and the association of aberrant signal processes with various diseases. Acquire insight into the immune system and its responses, and use this knowledge in the processes of immunization, vaccine development, transplantation and organ rejection.</p> <p>PSO4. To visualize and appreciate the central dogma of molecular biology, regulation of gene expression, molecular techniques used in rDNA technology, gene knock-out and knock-in techniques.</p> <p>PSO5. To create awareness in students about the importance of good laboratory practices and the importance of ethical and social responsibilities of a researcher. Teach them how to review literature and the art of designing and executing experiments independently and also work as a part of a team.</p>
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List of Courses:

Semester	Title of the Course	Core/Elective/ Soft Skill	Cred its	Interaction hrs /Week	Inter nal	End Semester exam
I	Bio molecules	Core	5	7	25	75
	Biochemical Techniques	Core	5	7	25	75
	Physiology and Cell Biology	Generic Elective	3	5	25	75
	Microbiology and Immunology	Core Elective	3	5	25	75
	Practical-I	Core	4	6	40	60
I I	Enzymes and Enzyme Technology	Core	4	6	25	75
	Cellular Metabolism with Clinical Correlation-I	Core	4	6	25	75
	Practical-II	Core	4	6	40	60
	Biostatistics and Data Science	Generic Elective	3	5	25	75
	Energy and drug Metabolism/Biochemical Toxicology	Core Elective	3	5	25	75
	Nutritional Biochemistry	Extra Disciplinary Paper	2	2	25	75
	Soft Skill-I	S	2	2	40	60
I I I	Clinical Biochemistry-I	Core	5	6	25	75
	Molecular Biology	Core	4	6	25	75
	Cellular Metabolism With Clinical Correlation-II	Core	4	6	25	75
	Practical-III	Core	4	6	40	60
	Cell Signaling	Core Elective	3	4	25	75
	Disease and Prevention	Extra Disciplinary Paper	2	2	25	75
	Soft Skill-II	S	2	2	40	60
	*Internship		2			100
I V	Hormones	Core	4	6	25	75
	Clinical Biochemistry-II	Core	4	6	25	75
	Applied Biotechnology	Core Elective	3	4	25	75
	*Project and viva	Core	6	8	20	80
	Pharmaceutical Biochemistry	Core Elective	3	4	25	75
	Soft Skill-III	S	2	2	40	60
	Extension Activity		1			

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

APPENDIX – 22(S) UNIVERSITY OF MADRAS
M.Sc. BIOCHEMISTRY
 SYLLABUS CBCS(w.e.f.2022-23)

Course	CORE PAPER I
Title of the Course:	BIOMOLECULES
Credits:	5
Pre-requisites, if any:	Basic Knowledge of Biomolecules
Course Objectives	<p>The main objectives of this course are to:</p> <ol style="list-style-type: none"> 1. Students will be introduced to the structure of biomolecules. 2. The significance of carbohydrates in biological processes 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 comprehend the role of membrane components with their biological significance. 5. Students will gain knowledge about the structures and functional roles of nucleic acids in the biological system
Course Outcomes	<p>On successful completion of the course, the students should be able to:</p> <p>CO1 : Explain the chemical structure and functions of carbohydrates. (K1, K2)</p> <p>CO2: Using the knowledge of lipid structure and function, explain how it plays a role in Signalling pathways (K3,K4)</p> <p>CO3: Describe the various levels of structural organisation of proteins and the role of proteins in biological system (K4, K5)</p> <p>CO4: Apply the knowledge of proteins in cell-cell interactions.(K3,K4)</p> <p>CO5. Applying the knowledge of nucleic acid sequencing in research and diagnosis (K2, K3,K4)</p>

Units	
I	Carbohydrates- Classification, structure (configurations and conformations, anomeric forms), function and properties of monosaccharides, mutarotation, Disaccharides and oligosaccharides with suitable examples . Polysaccharides - Homopolysaccharides (starch, glycogen, cellulose, inulin, dextrin, agar, pectin, dextran). Heteropolysaccharides - Glycosaminoglycans– source, structure, functions of hyaluronic acid, chondroitin sulphates, heparin, keratan sulphate,. Glycoproteins - proteoglycans. O- Linked and N-linked glycoproteins. Biological significance of glycan. Blood group
	polysaccharides. Bacterial cell wall (peptidoglycans, teichoic acid) and plant cell wall carbohydrates.
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, Rosemann Rossmann fold , Greek key),tertiary and quaternary structure of proteins. Structural characteristics of collagen and hemoglobin. Determination of amino acid sequence. Chemical synthesis of a peptide, Forces involved in stabilization of protein structure. Ramachandran plot. Folding of proteins. Molecular chaperons – Hsp 70 and Hsp 90 - biological role.
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 (Print and Online)	<ol style="list-style-type: none"> 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 6. https://nptel.ac.in/content/storage2/courses/102103012/pdf/mod3.pdf
Self-Study	<ol style="list-style-type: none"> 1. Classification of Sugars 2. Nutritional classification of fatty acids
Recommended Texts	<ol style="list-style-type: none"> 1. David L.Nelson and Michael M.Cox (2012) Lehninger Principles of Biochemistry (6th ed) W.H. Freeman. 2. Voet.D & Voet. J.G (2010) Biochemistry , (4th ed), JohnWiley & Sons, Inc. 3. Metzler D.E (2003). The chemical reactions of livingcells (2nd ed), Academic Press. 4. Zubay G.L (1999) Biochemistry , (4th ed), Mc Grew-Hill. 5. Lubert Stryer (2010) Biochemistry,(7th ed), W.H.Freeman 6. Satyanarayan,U (2014) Biochemistry (4th ed), ArunabhaSen Books & Allied (P) Ltd, Kolkata.

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

S- Strong

M-Medium

L-Low

Course	CORE PAPER II
Title of the Course:	BIOCHEMICAL TECHNIQUES
Credits:	5
Pre-requisites, if any:	Comprehensive Knowledge of Tools of Biochemistry
Course Objectives	<p>Biochemical techniques combine various inter-disciplinary methods in biological research and the course aims to provide students with the following objectives:</p> <ol style="list-style-type: none"> 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	<p>After completion of the course, the students should be able to:</p> <p>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)</p> <p>CO2. Demonstrate knowledge to implement the theoretical basis of chromatography in upcoming practical course work. (K3, K5)</p> <p>CO3. Demonstrate knowledge to implement the theoretical basis of electrophoretic techniques in research work. (K3, K5)</p> <p>CO4. Tackle more advanced and specialized spectroscopic techniques that are pertinent to research. (K1, K2 & K5)</p> <p>CO5. Tackle more advanced and specialized radioisotope and centrifugation techniques that are pertinent to research work. (K1, K2 & K5)</p>
Units	
I	<p>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.</p>
II	<p>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.</p>
III	<p>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.</p>

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	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 M-Medium L-Low

Course	GENERIC ELECTIVE -I
Title of the Course:	PHYSIOLOGY AND CELL BIOLOGY
Credits:	3
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	<p>After completion of the course, the students should be able to:</p> <p>CO1. specifically understand the biological and chemical processes within a human cell (K1, K2, K5, K6)</p> <p>CO2. identify and prevent diseases (K2, K3, K4, k5, K6)</p> <p>CO3. understand defects in digestion, nutritional deficiencies and intolerances, and gastrointestinal pathologies (K1, K2, K3, K4, K5, K6)</p> <p>CO4. identify general characteristics in individuals with imbalances of acid- base, fluid and electrolytes.(K1 , K2 , K3 , K4, K5, K6)</p> <p>CO5. process the mechanism: the transmission of biochemical information between cell membrane and nucleus. (K1, K2, K5)</p>
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.
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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 O ₂ and CO ₂ 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.
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	<ol style="list-style-type: none"> 1. Variation in cell differentiation and progression 2. Lesch Nyhan syndrome , orotic aciduria and GERD
Recommended Texts	<ol style="list-style-type: none"> 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.

	<ol style="list-style-type: none"> 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
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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	S	M	S	S	S	M
CO 2	S	S	S	S	S	L	S	S	S	M
CO 3	S	S	S	S	S	M	M	S	S	M
CO 4	S	S	S	S	S	M	M	S	S	M
CO 5	M	S	L	S	S	L	M	M	L	L

S-Strong M-Medium L-Low

Course	CORE ELECTIVE -I
Title of the Course:	MICROBIOLOGY & IMMUNOLOGY
Credits:	3

Pre-requisites, if any:	The student should possess basic knowledge about microorganisms, types and their general characteristics. The students are also expected to possess basic understanding about the process of infection, immunological defence and pathological outcomes, if any.
Course Objectives	<ol style="list-style-type: none"> 1. To appreciate the classification of microorganisms based on their structure, size and shape with an insight into the ancient scriptures about microbes. 2. To understand the role of microorganisms in environment and also to learn the culture conditions. 3. To recognize the possible contamination of foods by microorganisms, to learn about counteracting preservative measures and to know about probiotic nature of microorganisms. 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 to explore natural remedial measures against microbes. 6. To be able to exploit the various features of microorganisms for the beneficial industrial production.
Course Outcomes	<p>After completion of the course, the students should be able to:</p> <p>CO1. To classify (by both ancient and modern modes) different types of microorganisms and explain life cycle of the microbes (K1, K2 & K5)</p> <p>CO2. To recognize the microorganisms involved in decay of foods and will be able to apply various counteracting measures. The students also will be able to relate the role of certain beneficial microbes in day-to-day's food consumption. (K1, K2 & K4)</p> <p>CO3. To understand the common pathogenic bacterial and fungi that cause toxic effects and also will be able to employ curative measures. (K1 & K2)</p> <p>CO4. To analyse various features of wide variety of antimicrobial agents along with their mode of action, in addition, being able to apprehend the valuable potentials of traditional and easily available herbs. (K2, K5 & K6)</p> <p>CO5. To apply knowledge gained in production of industrially important products as both pharmaceutical and nutraceutical. (K2, K4 & K5)</p>
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 (கேழ்வரகு கூழ்) and bread.
III	Food poisoning- bacterial food poisoning, <i>Salmonella</i> , <i>Clostridium botulinum</i> (botulism), <i>Staphylococcus aureus</i> , fungal food poisoning – aflatoxin, food infection – <i>Clostridium</i> , <i>Staphylococcus</i> and <i>Salmonella</i> . Pathogenic microorganisms, <i>E. coli</i> , <i>Pseudomonas</i> , <i>Klebsilla</i> , <i>Streptococcus</i> , <i>Haemophilus</i> , & <i>Mycobacterium</i> , causes, control, prevention, cure and safety. Food microbiological screening- 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- spectra of activity, mode of administration, mode of action, adverse effects and sensitivity test., Antiviral and antiretroviral agents, Antiviral RNA interference, natural intervention (Natural immunomodulators routinely used in Indian medical philosophy).
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 <i>tridoshas</i> 2. Microbial population and pH variations in different dairy products.
Recommended Texts	1. Michael J. Pelczar Jr. (2001) Microbiology (5th ed), McGraw Hill Education (India) Private Limited 2. Frazier WC, Westhoff DC, Vanitha NM (2010) Food Microbiology (5th ed), McGraw Hill Education (India) Private Limited 3. Willey J and Sherwood L (2011) Prescott's Microbiology (8th ed) McGraw Hill Education (India) 4. Ananthanarayanan, Paniker and Arti Kapil (2013) Textbook of Microbiology (9th ed) Orient BlackSwan 5. Judy Owen, Jenni Punt Kuby (2013) Immunology (Kindt, Kuby Immunology) (7th ed) W. H. Freeman & Co 6. Brooks GF and Carroll KC (2013) Jawetz Melnick & Adelbergs Medical Microbiology, (26th ed) McGraw Hill Education 7. Greenwood D (2012) Medical Microbiology, Elsevier Health

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	CORE PAPER III
Title of the Course:	LABORATORY COURSE ON BIOMOLECULES AND BIOCHEMICAL TECHNIQUES
Credits:	4
Pre-requisites	Knowledge on basic principles, Instrumentation of Biochemical techniques and metabolic reactions
Course Objectives	<ol style="list-style-type: none"> 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	<p>On successful completion of this course, students should be able to:</p> <p>After completion of the course, the students should be able to:</p> <p>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)</p> <p>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).</p>

	<p>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,)</p> <p>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)</p> <p>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)</p>
Units	
I	<p>Biochemical studies and estimation of macromolecules</p> <ol style="list-style-type: none"> 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	<p>UV absorption</p> <ol style="list-style-type: none"> 1. Denaturation of DNA and absorption studies at 260nm. 2. Denaturation of Protein and absorption studies at 280nm.
III	<p>Colorimetric estimations</p> <ol style="list-style-type: none"> 1. Estimation of Pyruvate 2. Estimation of tryptophan.
IV	<p>Estimation of minerals</p> <ol style="list-style-type: none"> 1. Estimation of calcium 2. Estimation of iron
V	<p>Plant Biochemistry</p> <ol style="list-style-type: none"> 1. Qualitative analysis Phytochemical screening 2. Estimation of Flavonoids -Quantitative analysis
VI	<p>Group Experiments</p> <ol style="list-style-type: none"> 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..

	<p>4. Separation of plant pigments from leaves by column chromatography</p> <p>5. Identification of Sugars by Paper Chromatography</p> <p>6. Identification of Amino acids by Paper Chromatography</p>
Reading List (Print and Online)	<p>1. https://www.researchgate.net/publication/313745155_Practical_Biochemistry_A_Student_Companion</p> <p>2. https://doi.org/10.1186/s13020-018-0177-x</p> <p>3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5368116/</p> <p>4. https://www.life.illinois.edu/biochem/455/Lab%20exercises/2Photometry/spectrophotometry.pdf</p> <p>5. https://ijpsr.com/bft-article/determination-of-total-flavonoid-and-phenol-content-in-mimusops-elengi-linn/?view=fulltext</p> <p>6. https://skyfox.co/wp-content/uploads/2020/12/Practical-Manual-of-Biochemistry.pdf</p>
Self-Study	<p>1. Laboratory Safety Rules, Requirements and Regulations.</p> <p>2. Preparation of standard solutions and reagent</p>
Books Recommended	<p>1. David Plummer (2001) An Introduction to Practical Biochemistry (3rd ed) McGraw Hill Education (India) Private Ltd</p> <p>2. Jayaraman, J (2011), laboratory Manual in Biochemistry, New age publishers</p> <p>3. Varley H (2006) Practical Clinical Biochemistry (6th ed) , CBS Publishers</p> <p>4. O. Debiyi and F. A. Sofowora, (1978) "Phytochemical screening of medical plants," Iloyidia, vol. 3, pp. 234–246,</p> <p>5. Prof. Sarin A. Chavhan, Prof. Sushilkumar A. Shinde (2019) A Guide to Chromatography Techniques Edition:1</p> <p>6. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan. Springer (2011)</p>

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	CORE PAPER IV
Title of the Course:	ENZYMES AND ENZYME TECHNOLOGY
Credits:	4
Pre-requisites	Basic knowledge about catalysis, kinetics and chemical reaction mechanisms.
Course Objectives	<ol style="list-style-type: none"> 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.
	<ol style="list-style-type: none"> 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	<p>On successful completion of this course, students should be able to:</p> <p>CO1: Describe the catalytic mechanisms employed by enzymes (K1, K2 & K5)</p> <p>CO2: Choose and use the appropriate methods to isolate and purify enzymes and check the purity of the enzyme. (K1, K2, K3, K4 & K5)</p> <p>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)</p> <p>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)</p> <p>CO5: Highlight the use of enzymes in industries and biomedicine (K1, K2 & K3)</p>

Units	
I	<p>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.</p> <p>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</p>
II	<p>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</p>
III	<p>Enzyme kinetics I: Thermodynamics of enzyme action, Activation energy, transition-state theory, steady-state kinetics & pre-steady-state kinetics. Single substrate enzyme catalyzed reactions -assumptions, Michaelis-Menten and Briggs-Haldane kinetics, derivation of Michaelis-Menten equation . Double reciprocal (Lineweaver-Burk) and single reciprocal (Eadie -Hofstee) linear plots, their advantages and limitations. Analysis of kinetic data- determination of K_m, V_{max}, k_{cat}, and their physiological significance, Importance of k_{cat}/K_m. 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).</p> <p>Demonstration :Using Microsoft Excel to Plot and Analyze Kinetic Data</p>

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 glycogensynthase 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)	<p>Enzymes MIT OpenCourseWare Free Online Course Materials https://ocw.mit.edu/high-school/biology/exam-prep/chemistry-of-life/enzymes/</p> <p>Enzymology https://onlinecourses.swayam2.ac.in/cec20_bt20/preview https://mooc.es/course/enzymology/</p> <p>The active site of enzymes https://dth.ac.in/medical/courses/biochemistry/block-1/1/index.php</p> <p>Enzymes and Enzyme Kinetics https://www.lecturio.com/medical-courses/enzymes-and-enzyme-kinetics.course#/</p> <p>Mechanistic enzymology in drug discovery: a fresh perspective https://www.nature.com/articles/nrd.2017.219</p> <p>Enzyme Biosensors for Biomedical Applications: Strategies for Safeguarding Analytical Performances in Biological Fluids https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4934206/</p>
Self-Study	<ol style="list-style-type: none"> 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
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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	CORE PAPER V
Title of the Course:	CELLULAR METABOLISM WITH CLINICAL CORRELATION-I
Credits:	4
Pre-requisites	Basic knowledge on biochemical reactions such as addition, deletion, rearrangement, transfer and breaking of bonds
Course Objectives	<ol style="list-style-type: none"> 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	<p>On successful completion of this course, students should be able to:</p> <p>After completion of the course, the students should be able to:</p> <p>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)</p> <p>CO2. Gain knowledge on polysaccharide metabolism and glycogen storage disease (K1, K2, K5)</p> <p>CO3. Acquaint with the making and braking of nucleotides (K1,K2,K4)</p> <p>CO4. Differentiate the diverse reaction a particular amino acid can experience (K1,K2,K3)</p> <p>CO5. Correlate the disturbance of metabolic reactions to clinical manifestations with reference to heme and sulphur metabolism (K1, K2, K4, K5)</p>
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
II	Pentose phosphate pathway- significance and its regulation. Metabolism of glycogen and its regulation. Glycogen storage diseases -causes and symptoms. Uronic acid pathway. Biosynthesis of N-linked and O-linked glycoproteins, mucopolysaccharides- Chondroitin sulphate – Mucopolysaccharidoses with reference to Morquio syndrome A , Biosynthesis of bacterial cell wall polysaccharide.
III	Metabolism of nucleotides- De novo synthesis and salvage pathways of purine and pyrimidine nucleotides. Regulation and inhibitors of nucleotide biosynthesis. Role of ribonucleotide reductase and its regulation. Degradation of purine and pyrimidine nucleotides. Disorders of nucleic acid metabolism – LeschNyhan syndrome, Gout, Xanthinuria, Orotic Aciduria.
IV	Versatile role of PLP as coenzyme.-transamination, deamination and decarboxylation. Trans methylation and one carbon transfer. Biochemical manifestation of ammonia intoxication. Regulation of urea cycle, Inherited disorders of urea cycle enzymes. Conversion of amino acids to specialized products- Serotonin, GABA, epinephrine, nor-epinephrine, melanin, creatinine and NAD.
V	Biosynthesis and degradation of heme. Jaundice-classification, pathology and Differential diagnosis Oxidation and reduction of inorganic sulphur compounds by microbes and plants. Sulpho transferases and their biological role-rhodanases, sulphatases , 3- mercapto pyruvate sulphur transferases. Mucopolysaccharidoses - Hunter syndrome, Sanfilippo syndrome and Maroteaux-Lamysyndrome. Oxidation of cysteine to sulphate and inter conversion of sulphur compounds.
Reading List (Print and Online)	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 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

	<p>2. Voet.D and Voet. J.G (2010) Biochemistry , (4th ed), John Wiley & Sons, Inc.</p> <p>3. Metzler D.E (2003). The chemical reactions of living cells (2nd ed), Academic Press.</p> <p>4. Zubay G.L (1999) Biochemistry , (4th ed), Mc Grew-Hill.</p> <p>5. Textbook of Biochemistry with Clinical Correlations, 7th Edition, Thomas M. Devlin (Editor), Wiley</p> <p>6. Human Biochemistry – James M.Orten & Otto.W.Neuhan- 10th edn- The C.V.Mosby Company</p>
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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	CORE PAPER -VI
Title of the Course:	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	<ol style="list-style-type: none"> 1. To inculcate skill in students enabling them to apprehend the wider knowledge about principles and techniques to be employed for the assay of enzymes under investigation. 2. To inculcate the knowledge of isolation and purification techniques of enzymes using alkaline phosphatase as an example 3. To perform experiments to study the factors affecting enzyme activity 4. To achieve training in assay of enzymes 5. To achieve training in basic microbiological techniques – preparation of culture, sterilization and staining methods. 6. To perform the blood grouping test and to prepare blood smear to study different types of blood cells 7. To learn molecular biology techniques like Gel electrophoresis and Blotting techniques 8. To introduce industrial visit so that students may be aware of actual need of the industry and various opportunities available
Course Outcomes	<p>On successful completion of this course, students should be able to:</p> <p>After completion of the course, the students should be able to:</p> <p>CO1. The student will be able to employ the relevant techniques for isolation and purification of enzymes and gain skill in kinetic studies which is essential for research activity (K1,K2, K4)</p> <p>CO2. Student will acquire ability in performing enzyme assay, and explicate the methods that form the basis of enzyme characterization. (K1,K2,K4)</p> <p>CO3. Learn the Basic concepts in microbiology and cell biology which will be helpful for interdisciplinary research work. (K1,K3,K4)</p> <p>CO4. Students will be trained in separation techniques used in molecular Biology which will be supportive in their future research (K1,K3,K4 & K6)</p> <p>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)</p>
Units	

	<p>Enzymology</p> <p>Alkaline Phosphatase</p> <ol style="list-style-type: none"> Isolation of Alkaline Phosphatase from goat kidney. Purification of alkaline phosphatase Checking the purity using SDS-PAGE Determination of optimum pH and temperature of alkaline phosphatase. Determination of specific activity and K_m of alkaline phosphatase. Effect of activators and inhibitors on the activity of alkaline phosphatase. <p>Assay of enzymes A. Salivary Amylase B. Acid Phosphatase</p>
II	<p>Microbiology</p> <ol style="list-style-type: none"> Safety measures and Good Laboratory Practices in microbiology laboratory Sterilization, Culture and inoculum preparation Staining of bacteria – Gram Staining
III	<p>Physiology & Cell Biology</p> <ol style="list-style-type: none"> Test for blood grouping (Haemagglutination). Peripheral Blood smear – Staining and Interpretation
IV	<p>Group Experiments</p> <ol style="list-style-type: none"> Separation of proteins based on molecular weight by SDS PAGE Agarose gel electrophoresis of genomic DNA
V	<p>Industrial visit can be organised to students through Academia – Industry collaborative Program</p>
Reading List (Print and Online)	<ol style="list-style-type: none"> https://www.researchgate.net/publication/337146254_Kinetic_studies_with_alkaline_phosphatase https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4846332/ https://www.ijsr.net/archive/v3i8/MDIwMTU0MDk=.pdf https://www.researchgate.net/publication/349318898_ABC_of_Peripheral_smear https://ncdc.gov.in/WriteReadData/1892s/File608.pdf https://www.ncbi.nlm.nih.gov/books/NBK562156/
Self-Study	<ol style="list-style-type: none"> Preparation of Buffers and pH measurement Michaelis-Menten equation and Lineweaver Burk plot
Books Recommended	<ol style="list-style-type: none"> David Plummer (2001) An Introduction to Practical Biochemistry 3rd ed) McGraw Hill Education (India) Private Ltd Jayaraman, J (2011), laboratory Manual in Biochemistry, New age publishers Fundamentals of Enzymology; 3rd Edn. Nicholas C. Price and Lewis Stevens, Oxford University Press (2012). Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis; Robert A. Copeland, Wiley-VCH Publishers (2000). Cappuccino JG & Sherman N (2005). Microbiology-A Laboratory

	Manual, Pearson Education Inc 3. Practical Enzymology, Second Revised Edition: Hans Bisswanger, Wiley – Blackwell; 2 edition (2011)
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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	GENERIC ELECTIVE-II
Title of the Course:	BIOSTATISTICS & DATA SCIENCE
Credits:	3
Pre-requisites, if any:	Basic knowledge of Statistics and Computer Applications

Course Objectives	<ol style="list-style-type: none"> 1. To summarize the data and to obtain its salient features from the vast mass of original data. 2. To understand the concept of various measures of dispersion. 3. To understand the concepts of sampling and learning test of significance. 4. To understand the concept of various attributes and relate to biological studies. 5. To gain knowledge in SPSS, a software package which gives a perfect graphical representation and appropriate result for the data that has been entered
Course Outcomes	<p>After completion of the course, the students should be able to:</p> <p>CO1: Concepts of statistical population and sample, variables and attributes. Tabular and graphical representation of data based on variables.(K1,K2,K3)</p> <p>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)</p> <p>CO3:Learning different sampling methods and analysing statistical significance.(K1,K2,K3,K4)</p> <p>CO4: Understanding students t test , ANOVA , Chi square test to analyse the significance of various research. (K1,K2,K3,K4)</p> <p>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)</p>
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)	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 1. Zar, J.H. (1984) “Bio Statistical Methods”, Prentice Hall, International Edition 2. Sundar Rao P. S.S., Jesudian G. & Richard J. (1987), “An Introduction to Biostatistics”, 2nd edition, Prestographik, Vellore, India,. 3. Warren, J; Gregory, E; Grant, R (2004), “Statistical Methods in Bioinformatics”, 1st edition, Springer 4. Milton, J.S. (1992), “Statistical methods in the Biological and Health Sciences”, 2nd edition, Mc Graw Hill, 5. Rosner, B (2005), “Fundamentals of Biostatistics”, Duxbury Press 6. Introducing Data Science, Davy Cielen, Anro DB Meysman, Mohamed Ali.

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
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Methods of assessment:

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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	CORE ELECTIVE - II
Title of the Course:	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	<ol style="list-style-type: none"> 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	<p>On successful completion of this course, students should be able to:</p> <p>After completion of the course, the students should be able to:</p> <p>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)</p> <p>CO2. Gain knowledge on role of mitochondria in the production of energy currency of the cell (K1, K2, K5, K6)</p>

	<p>CO3. Acquaint with the process of photosynthesis (K1,K2,K5)</p> <p>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)</p> <p>CO5. Correlate the avenues available to metabolize the xenobiotics (K1, K2,K4,K5)</p>
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 F ₀ -F ₁ 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 CF ₀ -CF ₁ ATPase. Dark reaction- Calvin cycle, control of C ₃ pathway, and Hatch-Slack pathway (C ₄ 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)	<ol style="list-style-type: none"> https://chemed.chem.purdue.edu/genchem/topicreview/bp/ch21/gibbs.php https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7767752/#:~:text=The%20mitochondrial%20electron%20transport%20chain,cellular%20ATP%20through%20oxidative%20phosphorylation. https://www.researchgate.net/figure/Oxidative-phosphorylation-in-mitochondrial-electron-transport-chain-ETC-and-proton_fig1_230798915

	<p>4. https://www.lyndhurstschools.net/userfiles/84/Classes/851/photosynthesis%20light%20&%20dark%20reactions%20ppt.pdf?id=560837</p> <p>5. https://bajan.files.wordpress.com/2010/05/amphibolic-nature-of-krebs-cycle.pdf</p> <p>6. https://www.sciencedirect.com/topics/medicine-and-dentistry/xenobiotic-metabolism#:~:text=Xenobiotic%20metabolism%20can%20be%20defined,more%20readily%20excreted%20hydrophilic%20metabolites</p>
Self-Study	<p>1. Calculation of K_{eq} and G</p> <p>2. Interrelationship of carbohydrate, protein, and fat metabolism-role of acetyl CoA</p>
Recommended Texts	<p>1. David L.Nelson and Michael M.Cox (2012) Lehninger Principles of Biochemistry (6th ed), W.H.Freeman</p> <p>2. Robert K. Murray, Darryl K. Granner, Peter A. Mayes, and Victor W. Rodwell (2012), Harper's Illustrated Biochemistry, (29th ed), McGraw-Hill Medical</p> <p>3. Metzler D.E (2003). The chemical reactions of living cells (2nd ed), Academic Press.</p> <p>4. Zubay G.L (1999) Biochemistry , (4th ed), Mc Grew-Hill.</p> <p>5. Devlin RM (1983) Plant Physiology (4th ed), PWS publishers</p> <p>6. Taiz L , Zeiger E (2010), Plant Physiology (5th ed), Sinauer Associates, Inc</p>

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 I	CORE ELECTIVE-II
Title of the Course:	BIOCHEMICAL TOXICOLOGY
Credits:	3
Pre-requisites, if any:	The student should have a basic knowledge of pharmacology of drug action and understanding on their biochemical pathways.
Course Objectives	<ol style="list-style-type: none"> 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	<p>On completion of this course, the student will be able</p> <p>CO1: To appreciate and understand the role of toxicological biomarkers to assess drug toxicities.</p> <p>CO2: To conceive the role of disposition of drug in human system and their metabolism and methodologies pertaining to toxicological studies.</p> <p>CO3: To understand and evaluate the functions of different organs on drug disposition and associated drug toxicities.</p> <p>CO4 : To understand the toxicological response to foreign compounds and their pharmacological, physiological and biochemical effects.</p> <p>CO5: To link the mechanism of toxicity and clinical symptoms with underlying physiological disturbances.</p>
Units	
I	<p>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</p>

	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 Trials by Joy A. Cavagnaro 2. A Comprehensive Guide to Toxicology in Nonclinical Drug Development 2nd Edition by 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) - 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	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	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)

Course Outcomes	<p>After completion of the course, the students should be able to:</p> <p>CO1. Plan a balanced diet based on an individual's energy requirement, Assess nutritional status of an individual(K3, K4, K5)</p> <p>CO2. Describe the biochemical , physiological and nutritional functions of macronutrients and their integrated role. Understand the role played by antinutritional factors(k! to K6)</p> <p>CO3. Evaluate the functions of vitamins and minerals ,and fluids and electrolyte balance in different physiological states and in sports persons(K1 to K6)</p> <p>CO4. Identify nutritional deficiency conditions , its prevention and dietary management((K3,K4)</p> <p>CO5. Acquire knowledge about the importance of balanced diet and diet therapy (k5,K6)</p>
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)	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 1. Antabuse drugs and food 2. Selection of foods and market visit, reading and understanding the food labels
Recommended Texts	<ol style="list-style-type: none"> 1. Srilakshmi. E .(2016) Nutrition Science, New Age International Publishers. 2. Mahan, Kathleen L. (2004) Krause’s Food, Nutrition and DietTherapy, W.B.Saunders’s 11th Edition 3. Andreas M. Papas (1998). Antioxidant Status, Diet, Nutrition, and Health (1st ed) CRC Press. 4. M. Swaminathan (1995) Principles of Nutrition and Dietetics. Bappco 5. Margaret Mc Williams (2012). Food Fundamentals (10th ed) Prentice Hall 6. Tom Brody (1998) Nutritional Biochemistry (2nd ed). Academic Press, USA

Method of Evaluation:

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

Methods of assessment:

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

Understand/ Comprehend (K2) - MCQ, True/False, Short essays, Concept explanations, Shortsummary 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	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 VII
Title of the Course:	CLINICAL BIOCHEMISTRY I
Credits:	5
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	<ol style="list-style-type: none"> 1. To understand the need and methods of various biological sample collection. 2. To explicitly understand the etiopathogenesis, symptoms and complications of Diabetes Mellitus and the understand the relevant laboratory testing to evaluate the disease severity 3. To understand the haematological parameters to gauge pathological conditions associated with blood cells. 4. To understand the various disorders associated with electrolyte imbalance. 5. To understand the scope of clinical biochemistry testing in Medical Laboratory

Course Outcomes	<p>On completion of this course, the student will be able</p> <p>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</p> <p>CO2: To understand the etiology of metabolic diseases like diabetes mellitus so as to modify the lifestyle and correlate the symptoms with underlying pathology based on diagnostic and prognostic markers.</p> <p>CO3: To understand the anemia and evaluate clotting based on specific diagnostic markers and look for HBA1C variants</p> <p>CO4: To understand the clinical significance of electrolyte imbalance which is critical 0</p> <p>CO5: To understand the quality of testing clinical biochemistry parameters in laboratory with accuracy and precision using standard and updated methods.</p>
Units	
I	<p>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;</p>
II	<p>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, Micralbuminuria, eGFR.</p> <p>Point of care testing for glucose (Glucometers) and continuous glucose monitoring (CGM) : principle and its use.</p> <p>Major groups of anti-diabetic drugs. Diet and lifestyle modifications</p>
III	<p>Disorders of Blood cells: Hemolytic, iron deficiency and aplastic anemia and diagnosis, sickle cell anaemia, thalassemia HBA1C variants. Porphyrrias, 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.</p>
IV	<p>Electrolyte imbalance: Calcium: hypercalcemia and hypocalcemia; Calcium homeostasis in blood;</p> <p>Phosphorus: hyperphosphatemia or hypophosphatemia;;</p> <p>Clinical significance of Serum Bicarbonate</p> <p>Potassium: hyperkalemia and hypokalemia,</p> <p>Sodium: hypernatremia and hyponatremia;</p> <p>Chloride: hyperchloremia and hypochloremia</p>

V	<p>Variables in the Phases of analysis of biochemical parameters in clinical Laboratory:</p> <p>Pre-analytical phase: acceptance rejection criteria for specimen in terms of haemolysis/icteric/lipemia (HIL) interferences</p> <p>Analytical phase: Linearity, detection limits precision, accuracy, specificity, sensitivity; Total Allowable Error. (Definitions and examples).</p> <p>Post-analytical phase: Reporting of clinical chemistry parameters, Biological reference range and critical alert.</p> <p>The concept of Clinical chemistry Auto analyzers, Electrolyte analyzers (ion-specific electrode), Chemiluminescence Immunoassay (CLIA).</p>
Self-Study	<p>Quality control and Laboratory Information system</p> <ul style="list-style-type: none"> • Quality control for clinical chemistry in laboratory: west guard rules, six sigma. • Electronic data, Laboratory information system (LIS) • Biological reference ranges (CLIA guidelines., critical / alert values • American Diabetes Association (ADA) Standards of Medical Care in Diabetes (yearly update); HBA1C testing :NGSP • Ethics in Laboratory and Good Laboratory Practices • Safety in Laboratory, Material Safety Data sheet (MSDS)
Reading List (Print and Online)	<p>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</p> <p>2. Pre, Post and Analytical Errors in Clinical Chemistry laboratory DOI: 10.7860/NJLM/2016/22587:2173 https://doi.org/10.2147/JMDH.S286679</p> <p>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/</p> <p>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</p> <p>5. Laboratory Safety Guidance</p>

	https://www.osha.gov/sites/default/files/publications/OSHA3404laboratory-safety-guidance.pdf
Recommended Texts	<ol style="list-style-type: none"> 1. Thomas M. 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. M.N. Chatterjee and Rana Shinde (2012). Textbook of Medical Biochemistry (8th ed), Jaypee Brothers Medical Publishers. 6. Clinical Case Discussion In Biochemistry A Book On Early Clinical Exposure (ECE), Poonam Agrawal, 2021, CBS Publishers & distributors pvt. Ltd 7. R. N. Walmsley, G. H. White, (1994) A Guide to Diagnostic Clinical Chemistry, 3rd edition, Blackwell Scientific Publications.

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.

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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 –VIII
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	<ol style="list-style-type: none"> 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	<p>After completion of the course, the students should be able to:</p> <p>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)</p> <p>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)</p> <p>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)</p> <p>CO4: Comprehend the techniques of gene silencing and its applications.(K1,K2,K3,K4,K5,K6)</p> <p>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)</p>

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 <i>E.coli</i> , site specific recombination, transposons and retroposons.
III	<p>Transcription – Prokaryotic transcription-subunits of RNA polymerase, <i>E. coli</i> promoters, sigma factor and promoter recognition, alternativesigma factors, initiation, elongation, Rho-dependent and independent termination of transcription. Eukaryotic transcription- Initiation, promoter elements, RNA polymerases, transcription factors, regulatory sequences ineukaryotic protein – coding genes, CpG islands, enhancers.</p> <p>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 <i>E. coli</i>. The role of tRNA and rRNA, suppressor tRNAs and inhibitors of protein synthesis., Comparison of prokaryotic translation with eukaryotic translation.</p>
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. <i>Trp</i> operon – Attenuation, alternative secondary structures of <i>trp</i> mRNA. Regulation of gene expression in eukaryotes- Response elements, DNA-binding motifs, steroid receptors, association of methylation and histone acetylation with gene expression.

V	<p>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</p> <p>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</p>
Reading List (Print and Online)	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 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 IX
Title of the Course:	CELLULAR METABOLISM WITH CLINICAL CORRELATION-II
Credits:	4
Pre-requisites	Basic knowledge on biochemical reactions such as addition, deletion, rearrangement, transfer and breaking of bonds
Course Objectives	<ol style="list-style-type: none"> 1. Familiarize on degradation and synthesis of fatty acids 2. Provide an insight into the metabolic path way of fats, phospholipid and sphingo lipid with clinical correlation 3. Inculcate knowledge on cholesterol and lipoprotein metabolism and disorders associated with it 4. Provide a platform to understand the biosynthesis of non-essential amino acids and inter conversion of amino acids 5. Educate on fate of amino acids upon degradation and the associated inborn error of amino acid metabolism

Course Outcomes	<p>On successful completion of this course, students should be able to:</p> <p>After completion of the course, the students should be able to:</p> <p>CO1. Appreciate the modes of synthesis and degradation of fatty acids and will be able to justify the production biologically active substances from arachidonic acid (K1,K2,K5)</p> <p>CO2. Gain knowledge on metabolism of compound lipids and its associated metabolic errors (K1, K2, K5)</p> <p>CO3. Acquaint with cholesterol and lipoprotein metabolism along with clinical manifestation upon metabolic disturbance (K1,K2,K4,K5)</p> <p>CO4. Differentiate the diverse ways of inter conversion of amino acids (K1,K2,K3)</p> <p>CO5. Correlate the disturbance of metabolic reactions to clinical manifestations with reference to amino acid degradation (K1, K2,K5,K6)</p>
Units	
I	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.
II	Biosynthesis and degradation of triacylglycerol, phosphoglycero lipids- lecithin, cephalin, plasmalogens and phosphatidyl inositol, Sphingolipid- sphingomyelin, cerebrosides, sulfatides, and gangliosides. Inborn errors of lipid metabolism-Taysach’s disease, Gaucher’s and Niemann-Pick disease-causes and symptoms
III	Cholesterol biosynthesis and its regulation. Hyperlipidemia – Atherosclerosis -causes symptoms and diagnosis. Hypolipidemic agents, Biosynthesis of bile acids. Lipoprotein metabolism-chylomicrons, VLDL, HDL and LDL. Hyper and - Hypolipoproteinemia- Types and pathology. Metabolism of glucocorticoids mineralocorticoids, androgen, estrogen and progesterone
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

V	Degradation of amino acids –glucogenic and ketogenic amino acids. Formation of acetate from leucine and aromatic amino acid, pyruvate from cysteine, threonine and hydroxy proline, α -keto glutarate from histidine and proline, succinate from methionine, threonine, valine and isoleucine, Oxaloacetate from aspartate, glycine and serine. Inborn errors of amino acid metabolism-phenyl ketonuria, Tyrosinemia, Maple syrup urine disease and alkaptonuria- causes and symptoms.
Reading List (Print and Online)	<ol style="list-style-type: none"> 1. https://bio.libretexts.org/Bookshelves/Biochemistry/Book%3A_Biochemistry_Free_and_Easy_(Ahern_and_Rajagopal)/06%3A_Metabolism_I_-Oxidative_Reductive_Processes/6.11%3A_Fatty_Acid_Oxidation 2. https://www.sciencedirect.com/topics/medicine-and-dentistry/phospholipid-synthesis#:~:text=Phospholipid%20biosynthesis%20is%20linked%20to,NADH%2C%20catalyzed%20by%20glycerophosphate%20dehydrogenase. 3. https://www.ncbi.nlm.nih.gov/books/NBK459188/ 4. https://www.researchgate.net/publication/332042936_Introductory_Chapter_Overview_of_Lipoprotein_Metabolism 5. https://www.sciencedirect.com/topics/neuroscience/spermidine-synthase 6. https://accessmedicine.mhmedical.com/content.aspx?bookid=1366&sectionid=73244481&jumpsectionID=73244555
Self-Study	<ol style="list-style-type: none"> 1. Fate of propionyl CoA 2. Role of nonsteroidal anti-inflammatory drugs on cyclooxygenase
Books Recommended	<ol style="list-style-type: none"> 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 Graw-Hill. 5. Textbook of Biochemistry with Clinical Correlations, 7th Edition, Thomas M. Devlin (Editor), Wiley 6. Text book of Medical Biochemistry- MN Chatterjea, Rana Shinde, 8th Edition, Jaypee.

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, 51

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	CORE PAPER – X
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

<p>Course Objectives</p>	<ol style="list-style-type: none"> 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 . <ol style="list-style-type: none"> 7. To learn basic immuno techniques 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 Phlebotomy ,Collection and storage of specimen, Good laboratory practices, Automation and current methods adopted in the diagnostic Labs
<p>Course Outcomes</p>	<p>After completion of the course, the students should be able to:</p> <p>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)</p> <p>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)</p> <p>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)</p> <p>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)</p>

	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, Potassium 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)	<ol style="list-style-type: none"> 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/cli.html 3. https://www.researchgate.net/publication/263929434_Biochemistry 4. https://ucms.ac.in/Lectures-C-2020/Renal%20function%20Tests%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	1 Practical Clinical Biochemistry- Varley's by Alan H Gowenlock, published by CBS Publishers and distributors, India Sixth Edition ,1988. 2. Manipal Manual of Clinical Biochemistry (For Med.Lab.And Msc Stud.) 2013 (4 Edition) 3. Case Oriented Approach in Biochemistry-Dr. Rajesh Kawaduji Jambhulkar, Dr. Abhijit D. Ninghot: 2019 First Edition 4. Medical Lab Technology Vol I& II, Kanai L Mukerjee New Delhi: Tata Mcgraw Hill Publishing Company, 1996. 5. Practical Biochemistry – Plummer, New Delhi: Tata Mcgraw HillPublishing Company, 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.

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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	M	S	M	S	S	S
CO 5	S	S	S	S	S	S	S	S	S	S

S-Strong M-Medium L-Low

Course	CORE ELECTIVE
Title of the Course:	CELL SIGNALLING
Credits:	3
Pre-requisites, if any:	The student should have a basic knowledge of metabolism, cell structure, gene expression and protein structures. Student should possess basic knowledge in human anatomy and physiology to understand and correlate the function of hormones.
Course Objectives	<p>1. To understand the concept of signal transduction, Signalling pathways, various types of receptors and how the cell surface receptors use different downstream and upstream molecules to execute the signal transmission and exert a change in the metabolic and physiological processes.</p> <p>2. To understand the intricacy of interconnecting Signalling molecules that show diverse functions in various tissues.</p> <p>3. To understand the involvement of Signalling pathways and their components in hormonal regulation and relate their involvement in physiological functions.</p> <p>4. To understand how cell cycle is regulated by the binding of Signalling molecules to DNA.</p> <p>5. To understand the role of Signalling molecules in cancer progression.</p> <p>6. To create an awareness of how mutations in Signalling pathways lead to cancer.</p>
Course Outcomes	<p>After completion of the course, the students should be able to:</p> <p>CO1. To understand and explain the basic concepts of cell communication and Signalling, types of receptors, significance of Signalling and their role in manipulating life processes.</p> <p>CO2. To review the onward transmission of signal via downstream Signalling 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.</p> <p>CO3. To understand the role of enzymes in activating transcription factors by modification such as phosphorylation, proteolysis, removal from inhibitor.</p> <p>CO4. To appreciate the involvement of Signalling pathways in regulating cell cycle.</p> <p>CO5. To analyze the involvement of Signalling molecules in cancer progression.</p>
Units	

I	Basic concepts of cell Signalling, Receptor superfamilies and subtypes, intra cellular Signalling molecules-Adapter proteins, Molecular switches, Different Protein kinases (PKA, PKB, PKC and PKG) and protein phosphatases (I, 2A, 2B, PP2A), secondary messengers; Divergence, convergence, and cross talk.
II	G- protein coupled signal transduction pathways: Transmembrane Receptors–Structure, Major classes of trimeric G proteins based on Gs unit, mechanism of signal transmission, toxins as tools in characterization of G-protein, GTPase switches, cAMP, IP3 and calcium as second messengers in GPCR Signalling pathways, Calmodulin and CaM Kinases, NO as Signalling molecule, G proteins that regulate ion channels; G-protein and control of gene expression.
III	Signalling pathways that control gene activity – TGFbeta and SMADs, Cytokine receptors, JAK-STAT pathway, SOCS, Receptor Tyrosine Kinases (RTK), activation of Ras, genetic analysis – Drosophila eye development; MAPK; Phosphoinositide cascade. Downregulation of various Signalling pathways
IV	NF-kB; Signalling cascade. Outline of Notch and Wnt Signalling pathways. Steroid hormone Signalling - Mechanism of transcriptional regulation by nuclear receptors and transactivation.
V	Mutations of Signalling molecules and their impact in cell cycle. Mutations leading to overexpression of receptors and Signalling molecules. Mutations leading to truncated proteins and chimeric proteins-bcr-abl. Mutations in transcription factors and inhibitory proteins. Overview of involvement of Signalling cascades in cancer.
Self-Study	<ol style="list-style-type: none"> 1. Signalling pathways as targets for therapeutics 2. Yip HYK, Papa A. Signalling Pathways in Cancer: Therapeutic Targets, Combinatorial Treatments, and New Developments. Cells. 2021 Mar 16;10(3):659. doi: 10.3390/cells10030659. PMID: 33809714; PMCID: PMC8002322. 3. https://doi.org/10.3389/fonc.2020.01533
Reading List (Print and Online)	<ol style="list-style-type: none"> 1. Molecular cell Biology -Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Kelsey C. Martin. 8th edition, Published by WH Freeman and Company, USA (2016) . 2. Principles of Biochemistry by Lehninger, Nelson and Cox, 7th edition, published by W H Freeman and Company, New York, USA, 2017 3. Genes XI by Benjamin Lewin, Jocelyn E Krebs, Elliott S Goldstein, Stephen T Kilpatrick. 10th edition, published by Burlington, Mass.: Jones & Bartlett Learning, ©2014.

	<p>4. Cell Signalling Learn Science at Scitable – Nature https://www.nature.com › cell-Signalling-14047077</p> <p>5. Nair A, Chauhan P, Saha B, Kubatzky KF. Conceptual Evolution of Cell Signalling. Int J Mol Sci. 2019 Jul 4;20(13):3292. doi: 10.3390/ijms20133292. PMID: 31277491; PMCID: PMC6651758.</p>
Recommended Texts	<p>1. Biochemistry by Donald Voet and Judith Voet, 5th Edition, Published by John Wiley,USA, (2016)</p> <p>2. Molecular Biology of the cell-Bruce Alberts Alexander John, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter, sixth Edition, published by Garland Science, cop. USA (2015).</p> <p>3. Principles of Biochemistry with human focus by Garrett and, Harcourt College Publishers, Orlando, Florida, USA. 2005</p> <p>4. Principles of Biochemistry by Lehninger, Nelson and Cox, 7th edition, published by W H Freeman and Company, New York, USA, 2017</p>

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, Shortsummary 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	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	EXTRA DISCIPLINARY PAPER- II
Title of the Course:	DISEASE AND PREVENTION
Credits:	2
Pre-requisites, if any:	A knowledge on nutrition & dietetics. metabolism of nutrients and molecular basis of diseases
Course Objectives	<p>1. To highlight the connection among nutrition, lifestyle and the complex science of preventing disease.</p> <p>2. To promote optimal metabolic health, building on input from several complementary disciplines.</p> <p>3. Goal is to encourage epidemiological research in nutrition, and to be able to define better targets and intervention programmes. To understand diet - drug- lifestyle interactions, that can address health complex issues.</p>
Course Outcomes	<p>After completion of the course, the students should be able to:</p> <p>CO1. Understand the risks of development of obesity, cardiovascular diseases and diabetes mellitus , their treatment and prevention (K1 to K6)</p> <p>CO2. Effectively manage hypertension and renal diseases by making lifestyle and diet changes (K1 to K6)</p> <p>CO3. Be aware of carcinogenic agents , treatment modalities in cancer - side-effects (if any) ,drug- food interactions ,and also on diagnosis and prognosis of the disease (K1 to K6)</p> <p>CO4. Prevent pre- mature ageing and age related disorders / disease conditions (K1 to K6)</p> <p>CO5. Manage stress related gastrointestinal problems and gallstone formation (K1 to K6)</p>
Units	
I	Obesity- prevalence -causes, consequences, symptoms- Coronary Heart Disease and type 2 diabetes mellitus- lifestyle and dietary management of obesity. Diabetic foot care. Demonstration of CPR first-aid as a lifesaving technique.
II	Hypertension - blood pressure-normal level of blood pressure, dietary management of hypertension, stroke and chronic renal failure due to hypertension. Kidney stone- causes, types, symptoms and treatment (only Lithotropy), dietary management for prevention of kidney stones.

III	Cancer-types of cancer, etiology of breast cancer diagnosis (self-examination, Mammography) and treatment (radiation, chemotherapy, surgery). Cervical cancer-causes, Types of cervical cancer, symptoms, diagnosis and treatment (radiation(side-effects), chemotherapy(side-effects), surgery. Targeted endocrine/antibody therapies for cancer. Cigarette smoking and symptoms, diagnosis and treatment (chemotherapy)
IV	Ageing-Factors influencing ageing. Age related diseases- dementia, osteoporosis, Osteoarthritis - causes sign and symptoms, preventive measures of ageing with special reference to antioxidants
V	Gallstones- causes, factors, aetiology of gallstones, types of gallstones, symptoms, preventive aspects of gallstone. Drug therapy - ursodeoxy cholic acid, surgical treatment and dietary management. -Ulcer - causes and prevention.
Reading List (Print and Online)	<ol style="list-style-type: none"> 1. https://www.medicalnewstoday.com/articles/324712#cpr-step-by-step 2. https://www.mayoclinic.org/diseases-conditions/dementia/symptoms-causes/syc-20352013 3. https://www.webmd.com/diet/ss/slideshow-ketogenic-diet 4. https://www.nhs.uk/conditions/chemotherapy/side-effects/ 5. https://medlineplus.gov/ency/patientinstructions/000868.htm 6. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4336979/documentation
Self-Study	<ol style="list-style-type: none"> 1. Nature of antioxidants (Identify nutraceuticals and phytoconstituents) used for treatment of diseases 2. Gain knowledge on home made herbal recipes and herbal supplements
Recommended Texts	<ol style="list-style-type: none"> 1. Thomas M.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 (2014) (7th ed,Saunders. 4. Dinesh Puri (2002), Textbook of Biochemistry : A clinically oriented approach - Churchill Livingstone Inc., India 5. M.N.Chatterjee and Rana Shinde (2007).Textbook of Medical Biochemistry (7th ed) 6. Konnokova, S. (2008), Mama's Home Remedies, 1sted, Independent publishers, USA.

Method of Evaluation:

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

Methods of assessment:

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

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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	S	S	S	S	M
CO 2	S	S	S	M	S	S	S	S	S	M
CO 3	S	S	S	M	S	S	S	S	S	M
CO 4	S	S	S	M	S	S	S	S	S	M
CO 5	S	S	S	M	S	S	S	S	S	M

S-Strong M-Medium L-Low

Course I	CORE PAPER – XI
Title of the Course:	HORMONES
Credits:	4
Pre-requisites, if any:	The student should have a basic knowledge of signalling methods, structure of steroids, cell structure, gene expression and protein structures. Student should possess basic knowledge in human anatomy and physiology to understand and correlate the function of hormones.

<p>Course Objectives</p>	<ol style="list-style-type: none"> 1. To understand the different types of hormones that are secreted by various organs and glandular tissues. 2. To get an overview of how these hormones make a change in the expression of proteins / metabolism of the cell and manage the life processes towards homeostasis. 3. To assimilate the involvement of Signalling pathways and their components in hormonal action and correlate their involvement in physiological functions. 4. To understand how the hypothalamus-pituitary axis controls various activities of the body 5. To understand the role of hormones in spermatogenesis, oogenesis, menstrual cycle and ovarian cycle. 6. To kindle the ability of students to conceptualize the role of hormones in various physiological functions of the body.
<p>Course Outcomes</p>	<p>After completion of the course, the students should be able to:</p> <p>CO1. To understand and explain the different types and basic concepts of Signalling, types of hormones, significance of Signalling in manipulating life processes.</p> <p>CO2. To review the intricacy of hormones on metabolism and how stringently the network is regulated in a co-ordinated fashion resulting in the biological outcome.</p> <p>CO3. To analyze the involvement of hormones in various clinical conditions like diabetes, metabolic syndrome, obesity and reproductive health issues.</p> <p>CO4. To apply the knowledge acquired in daily life and try to resolve problems and create an awareness of approaches available to treat hormonal disorders.</p> <p>CO5. To critically analyse the underlying abnormality with the symptoms from childbirth till senescence.</p>
<p>Units</p>	
<p>I</p>	<p>Hormones – Classification, Biosynthesis, circulation in blood, modification and degradation. Mechanism of hormone action, Target cell concept. Hormones of Hypothalamus and pituitary hormones – Hypothalamic releasing factors, synthesis, secretion and biological role. Anterior pituitary hormones – Physiological actions and feedback regulation of synthesis. Growth promoting, Lactogenic hormones. Glycoprotein hormones, the POMC family, Endorphins – Biological functions Posterior Pituitary hormones – Synthesis, secretion and physiological action of Vasopressin and oxytocin Hypothalamus-Pituitary- Target organ axis and feedback regulation.</p>

II	Pancreatic hormones – cell types of the islets of Langerhans. Insulin – structure, Biosynthesis, regulation of secretion, Biological actions and mechanism of action. Glucagon, somatostatin and pancreatic polypeptide. Insulin like growth factors – structure, biological action. Gastrointestinal hormones – secretin, gastrin, cholecystokinin – biological action, regulation of secretion.
III	Biosynthesis, secretion, transport, biological action, metabolic fate of thyroid hormones. Role of thyroid hormones in metabolism, basal metabolic rate and functions of other organs. Biosynthesis, secretion, transport, biological action, metabolic fate of thyroid and parathyroid hormones. Role of parathyroid hormones in maintenance of calcium and phosphorus metabolism.
IV	Adrenal hormones – Glucocorticoids, mineralocorticoids, synthesis, secretion, transport, metabolism and excretion. Biological effects. Mechanisms of action, adrenal androgens, metabolic effects and functions. Adrenal medulla – Catecholamines, biosynthesis, storage, metabolism, regulation of synthesis and biological effects. Chemical nature and biological action of prostaglandins.
V	Gonadal Hormones – Chemical Nature and Biosynthesis. Physiological action of hormone in the regulation of spermatogenesis and oogenesis. Ovarian cycle. Menarche and Menopause. Role of hormones in implantation, gestation, parturition and lactation, Biochemical changes in pregnancy. Polycystic ovarian syndrome and Endometriosis. Contraception – Male and Female contraceptive methods, Types- Barrier methods (IUDs), hormonal contraceptives and Surgical methods. Infertility and treatment modalities.
Self-Study	<ol style="list-style-type: none"> 1. Inter relationship between sleep and hormones. Kim TW, Jeong JH, Hong SC. The impact of sleep and circadian disturbance on hormones and metabolism. <i>Int J Endocrinol</i>. 2015;2015:591729. doi: 10.1155/2015/591729. Epub 2015 Mar 11. PMID: 25861266; PMCID: PMC4377487. https://doi.org/10.1152/physrev.00010.2018 2. Role of Thyroid hormones in female reproduction Juneo F Silva, Natália M Ocarino, Rogéria Serakides 3. <i>Biology of Reproduction</i>, Volume 99, Issue 5, November 2018, Pages 907–921, https://doi.org/10.1093/biolre/iocy115

Reading List (Print and Online)	<ol style="list-style-type: none"> 1. Harrison’s Endocrinology by J. Larry Jameson Series: Harrison’s Specialty, 19th Edition Publisher: McGraw-Hill, Year: 2016. 2. Endocrinology by Thomas Fox, Antonia Brooke, Ijay Vaidya Series: Eureka Publisher: JP Medical Publishers, 5th Edition, Year: 2015. 3. Cellular Endocrinology in Health and Disease by Author(s): Alfredo Ulloa-Aguirre and P. Michael Conn (Eds.) Publisher: Academic Press, Year: 2014 4. Basic Clinical Endocrinology by Francis S., MD Greenspan, Gordon J., MD Strewler, 5th Edition, Published by Appleton & Lange, 5th Edition, Year: 2007. 5. Basic Medical Endocrinology by H. Maurice Goodman, 4th Edition, Publisher: Academic Press, Year: 2009, USA. 6. https://www.sfzg.unizg.hr/_download/repository/HORMONES_SKB_2020.pdf
Recommended Texts	<ol style="list-style-type: none"> 1. Endocrinology and Metabolism by Philip Felig, Lawrence A. Frohman, 4th edition, Publisher: McGraw-Hill Professional, Year: 2001, USA. 2. Williams Textbook of Endocrinology by Shlomo Melmed MBChB MACP, Ronald Koenig, Clifford Rosen, Richard Auchus, Allison Goldfine, Publisher: Elsevier, 14th Edition, Year: 2019, USA, 2021. 3. Manual of Endocrinology and Metabolism by Norman Lavin, Series: Lippincott Manual Series Publisher: Wolters Kluwer Health, 5th edition Year: 2018 4. Hormones and the Endocrine System: Textbook of Endocrinology by Bernhard Kleine, Winfried G. Rossmanith (auth.) Publisher: Springer International Publishing, Year: 2016, USA (2021).

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, Shortsummary 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	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 – XII
Title of the Course:	CLINICAL BIOCHEMISTRY-II
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	<ol style="list-style-type: none"> 1. To understand the Diagnostic application of enzymes in clinical Biochemistry 2. To understand the relevance and methods of pre- and post-natal diagnosis of various inherited metabolic disorders and the tools such as amniocentesis and tandem mass spectrometry 3. To understand the Liver function, tests to evaluate the liver function and the various disorders associated 4. To understand the Renal function, tests to evaluate the various causes of kidney dysfunction and failure <p>To understand Signalling mechanism from cell surface to the nucleus by different pathways resulting in the biological outcome and critically evaluate the network between the hormones as regulatory messengers to this effect.</p>

Course Outcomes	<p>On completion of this course, the student will be able</p> <p>CO1 : To appreciate and understand the role of enzymatic biomarkers to assess organ pathologies</p> <p>CO2 :To conceive the role of inherited genes in inherited disorders of metabolism and methodologies pertaining to <i>in utero</i> diagnosis and post-natal screening.</p> <p>CO3 :To understand and evaluate the functions of liver and to monitor the health of the organ based on specific laboratory tests and interpretations.</p> <p>CO4 :To understand and evaluate the functions of kidney and to monitor the health of the Renal system based on specific laboratory tests and interpretations.</p> <p>CO5 :To link the serum hormone levels and clinical symptoms with underlying hormonal disturbances.</p>
Units	
I	Diagnostic Enzymology: Clinically Important Enzymes and Isoenzyme as diagnostic markers : Clinical significance of AST, ALT, ALP, ACP, CK, γ -GT, amylase, pseudocholesterase Pattern in .Myocardial infarction; Liver disease, Bone disease, Muscle disease, Cancer (tumor markers), GI tract pancreatitis); Enzymes as therapeutic agents.
II	Pre and post natal testing: Amniocentesis, inherited metabolic disorders (IMD) and the various types ; Tandem mass spectrometry application for New born screening (NBS)
III	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)
IV	Renal function tests - Tests for glomerular and tubular function. Acute and chronic renal failure, Glomerulonephritis, Nephrotic syndrome, uremia, urinary calculi-Nephrocalcinosis and Nephrolithiasis, Chronic kidney disease and stages, Renal insufficiency and Renal failure, Dialysis-Hemodialysis and peritoneal dialysis.
V	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.
Self-Study	<ul style="list-style-type: none"> • Case studies to review

<p>Reading List (Print and Online)</p>	<ol style="list-style-type: none"> 1. Case studies in clinical biochemistry 2. Charles van Heyningen, Petko Ivanov., 2013., https://doi.org/10.1177/0004563213495139 3. https://quizlet.com/177974374/clinical-chemistry-and-case-studies-flash-cards/ 4. Biomedical waste management https://cpcb.nic.in/uploads/Projects/Bio-Medical-Waste/Guidelines_healthcare_June_2018.pdf 5. Ethics in laboratory medicine https://doi.org/10.1373/clinchem.2019.306670 6. Clinical Chemistry Laboratory Automation Armbruster DA, Overcash DR, Reyes J. Clinical Chemistry Laboratory Automation in the 21st Century - Amat Victoria curam (Victory loves careful preparation). ClinBiochem Rev. 2014 Aug;35(3):143-53. PMID: 25336760. 7. Good Laboratory practice https://dst.gov.in/oecd-principles-glp
<p>Recommended Texts</p>	<ol style="list-style-type: none"> 1. Thomas M.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) Textbook of Biochemistry: A clinically oriented approach – 4th Edition, Elsevier. 5. M.N.Chatterjee and Rana Shinde (2012).Textbook of Medical Biochemistry (8th ed), Jaypee Brothers Medical Publishers. 6. Clinical Case Discussion In Biochemistry A Book On Early Clinical Exposure (ECE), Poonam Agrawal , 2021, CBS Publishers & distributors pvt. Ltd 7. R. N. Walmsley, G. H. White, (1994) A Guide to Diagnostic Clinical Chemistry, 3rd edition, Blackwell Scientific Publications.

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.

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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	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 ELECTIVE -IV
Title of the Course:	APPLIED BIOTECHNOLOGY
Credits:	3
Pre-requisites, if any:	The students should possess detailed knowledge about structures and functions of DNA and proteins in addition to the basic laboratory techniques such as electrophoresis.
Course Objectives	<ol style="list-style-type: none"> 1. To train the student in techniques related to the generation of recombinant DNA, screening and to incorporate skills essential for various types of sequencing. 2. To introduce and also elaborate knowledge about wide varieties of vectors and their features in addition to their applications. 3. To educate about the characteristics of cell culture, production of transgenic animals with relevant safety/ethics involved and patents as well. <ol style="list-style-type: none"> 4. To inculcate practical knowledge on plant tissue culture, their propagation and exploitation of the techniques for crop improvement. <p>To theoretically train the students in various techniques for gene/protein manipulation, software/ databases with futuristic perspectives.</p>

Course Outcomes	<p>After completion of the course, the students should be able to:</p> <p>CO1. To produce recombinant molecule, screen the products and also to identify/analyse various DNA sequences using different methods. (K1, & K2)</p> <p>CO2. To clone gene of their interest for several downstream purposes with a robust comprehension about wide variety of applicable vectors. (K1, K2 & K5)</p> <p>CO3. To design animal cell culture protocols for transgenic applications with an acquaintance about ethical aspects. The students would also be enriched with ideas about intellectual property rights. (K2, K3 & K4)</p> <p>CO4. To successfully plan plant tissue culture, manipulate the cultures for commercially important plant products. (K2, K4 & K5)</p> <p>CO5. To exploit and apply the knowledge gained about the various laboratory techniques involving both DNA and protein manipulation along with software tools. The student will be persuaded to contemplate on upcoming technologies for futuristic benefits. (K2, K5 & K6)</p>
Units	
I	Basic techniques: Cutting DNA molecules, Restriction digestion, isoschizomers, joining DNA molecules – DNA ligase, double linkers, adaptors, homopolymer tailing, selection of recombinants and screening –
	genetic methods, immuno chemical methods, South-Western screening, Nucleic acid hybridization methods, synthesis of probes, radio-active and non-radioactive labelling of probes, analysing DNA sequences- methods: Automated sequencing, Pyro Sequencing, Next Generation Sequencing Analysis (NGS), <i>in silico</i> sequence analysis
II	Cloning strategies: Cloning vectors – plasmids (pBR 322, pUC 18), phage λ and M 13, cosmids, phasmids/ Phagemids, expression vectors, ; pMal; GST; pET-based vectors, Protein purification, His-tag; GST-tag; MBP-tag, Inclusion bodies- Methodologies to reduce formation of inclusion bodies, yeast vectors – YEP, YIP, YRP, YCP and YAC, shuttle vectors. Genomic DNA libraries, cDNA cloning, RACE, RAPD. Site directed mutagenesis of cloned genes.
III	Animal cell culture- media, primary culture, contamination, disaggregation, subculturing. Introduction of genes into animal cells: Reporter genes, selectable markers, viral vectors – SV 40, Retroviruses and Baculovirus, Adenoviruses, adeno-associated viruses, modifying vectors to alter tropism Transferring genes into animal cells in culture, oocytes, eggs, embryos and specific tissues, transgenic animals, Creation of knock out/knock in mice. Hazards, ethics and safety aspects of biotechnology. Patents and IPR.

IV	Plant tissue culture- media, callus and protoplast cultures. Production of biochemicals from plant cell culture. Micropropagation Agro bacterium – mediated gene transfer to plant cells, Plant based vectors, Ti and Ri as vectors, microprojectiles, transgenic plant technology – for pest resistance, herbicide tolerance, delay of fruit ripening and use of plants to produce commercially important proteins. Basics of CRISPR-Cas technology and its use in improvement of crops
V	Protein/ Gene technologies and their applications: Techniques for separation and identification of proteins, 2D-gel electrophoresis, mass spectrometry, MALDI-TOF. Protein arrays. The Human Genome Project-goals, results, potential benefits and risks, Genome mapping, types of gene map, molecular markers. DNA microarrays. Production of insulin and growth hormone in E. coli. Engineered proteins and their industrial applications (Enzymes: Trypsin and Proteases; Proteins: Interferons). Applications of proteomics. Bioinformatics- introduction, biological databases, database similarity searches- FASTA, BLAST. Multiple sequence alignment, construction of a phylogenetic tree.
Reading List (Print and Online)	<ol style="list-style-type: none"> 1. https://www.frontiersin.org/articles/10.3389/fpls.2018.00985/full (CRISPR for Crop Improvement: An Update Review) 2. doi: 10.1002/bab.2117 (Enzyme engineering and its industrial applications) 3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2759942/ (Analyses of regenerative wave patterns in adult hair follicle populations reveal macro-environmental regulation of stem cell activity) 4. https://emmind.net/scien/cap/Files/(45)%202011GariaevLinguistics.pdf (Principles of Linguistic-Wave Genetics) 5. http://molbiol.ru/forums/index.php?act=Attach&type=post&id=258095 (PCR Amplification of Phantom DNA Recorded as Potential Quantum Equivalent of Material DNA)
Self-Study	<ol style="list-style-type: none"> 1. Biotechnology in Ancient India by Saints 2. Grafting in production of hybrid varieties of flowers and fruits

Recomnded Texts	<ol style="list-style-type: none"> 1. David Freifelder (1992) Essentials of Molecular Biology (2nd ed) Jones & Bartlett Pub 2. Click B.R. and Pasternark J.J (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. (4th ed) American Society for Microbiology 3. James D. Watson , Amy A. Caudy , Richard M. Myers , Jan Witkowski (2006) , Recombinant DNA: Genes and Genomes - a Short Course (3rd ed), W.H. Freeman & Co 4. Satyanarayana U (2008), Biotechnology, Books & Allied (P) Ltd. 5. Brown TA, (2010) Gene Cloning and DNA Analysis (6th ed), Wiley-Blackwell 6. Green MR and Sambrook J (2012) Molecular Cloning: A Lab Manual(4th ed) Cold Spring Harbor Laboratory Press 7. Sandy B. Primrose and Richard M. Twyman (2002), Principles of Gene Manipulation(6th ed) Wiley-Blackwell 8. Upadhyay, S. K. (Ed.). (2021). <i>Genome Engineering for Crop Improvement</i>. John Wiley & Sons, Incorporated.
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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.

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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
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S-Strong M-Medium L-Low

Course I	CORE ELECTIVE-V
Title of the Course:	PHARMACEUTICAL BIOCHEMISTRY
Credits:	3
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	<ol style="list-style-type: none"> 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	<p>After completion of the course, the students should be able to:</p> <p>CO1. To understand and explain the basic concepts of drug discovery and drug development process.</p> <p>CO2. To review the different software and computational tools which aid in the design of drugs and its rationalization.</p> <p>CO3. To analyze the different stages of the drug discovery process with the target & hit identification, assays for drug screening and preclinical studies.</p> <p>CO4. To understand the various phases of the clinical trails and the method of conduct of clinical trails.</p>
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	<p>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.</p>
III	<p>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 K_d, B_{max} and IC₅₀.</p>
IV	<p>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.</p>
V	<p>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.</p>
Self-Study	<ol style="list-style-type: none"> 1. Examples of pharmaceutical development of a drug 2. Basic pharmacology of drug action and kinetics
Reading List (Print and Online)	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 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. TP. Kenakin. Elsevier, 1st Edn 2012.
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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
