

M.Sc BIOCHEMISTRY

(For the students admitted from 2023–2024 onwards)



DEPARTMENT OF BIOCHEMISTRY

RAJAH SERFOJI GOVERNMENT COLLEGE (AUTONOMOUS)

Accredited at 'A' Grade by NAAC & DST-FIST Sponsored College

**Thanjavur - 613 005, Tamil Nadu,
India**

Programme:	M.Sc BIOCHEMISTRY
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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Template for P.G., Programmes

Semester-I	Credit	Hours	Semester-II	Credit	H	Semester-III	Credit	Hours	Semester-IV	C	Ho
1.1. Core-I	5	7	2.1. Core-IV	5	6	3.1. Core-VII	5	6	4.1. Core-XI	5	6
1.2 Core-II	5	7	2.2 Core-V	5	6	3.2 Core-VIII	5	6	4.2 Core-XII	5	6
1.3 Core – III	4	6	2.3 Core – VI	4	6	3.3 Core – IX	5	6	4.3 Project with viva voce	7	10
1.4 Discipline Centric Elective -I	3	5	2.4 Discipline Centric Elective – III	3	4	3.4 Core – X	4	6	4.4 Elective - VI (Industry / Entrepreneurship) 20% Theory 80% Practical	3	4
1.5 Generic Elective-II:	3	5	2.5 Generic Elective -IV:	3	4	3.5 Discipline Centric Elective - V	3	3	4.5 Skill Enhancement course / Professional Competency Skill	2	4
			2.6 NME I			3.6 NME II			4.6 Extension Activity	1	
						3.7 Internship/ Industrial Activity					
	20									23	30
Total Credit Points -91											

Choice Based Credit System (CBCS), Learning Outcomes Based Curriculum Framework (LOCF) Guideline Based Credits and Hours Distribution System for all Post – Graduate Courses including Lab Hours

First Year – Semester – I

Part	List of Courses	Credits	No. of Hours
	Core – I	5	7
	Core – II	5	7
	Core – III	4	6
	Elective – I	3	5
	Elective – II	3	5
		20	30

Semester-II

Part	List of Courses	Credits	No. of Hours
	Core – IV	5	6
	Core – V	5	6
	Core – VI	4	6
	Elective – III	3	4
	Elective – IV	3	4
	Skill Enhancement Course [SEC] - I	2	4
		22	30

Second Year – Semester – III

Part	List of Courses	Credits	No. of Hours
	Core – VII	5	6
	Core – VIII	5	6
	Core – IX	5	6
	Core (Industry Module) – X	4	6
	Elective – V	3	3
	Skill Enhancement Course - II	2	3
	Internship / Industrial Activity [Credits]	2	-
		26	30

Semester-IV

Part	List of Courses	Credits	No. of Hours
	Core – XI	5	6
	Core – XII	5	6
	Project with VIVA VOCE	7	10
	Elective – VI (Industry Entrepreneurship)	3	4
	Skill Enhancement Course – III / Professional Competency Skill	2	4
	Extension Activity	1	-
		23	30

Total 91 Credits for PG Courses

RAJAH SERFOJI GOVERNMENT COLLEGE (AUTONOMOUS)

Thanjavur-5

M.Sc. Biochemistry

Curriculum FOR 2023-24 ONWARDS

Sem	PART	Sub. Code	Title of the Course	Core/Elective Soft Skill	Credits	Tutorial Hours	Marks		
							Int	Ext	Total
I	III	T1PBCC1	Basics of Biochemistry	1.1 Core-I	5	7	25	75	100
	III	T1PBCC2	Physiology and Cell Biology	1.2 Core-II	5	7	25	75	100
	III	T1PBCC3	Practical I- Bioorganic Analysis	1.3 Core-III	4	6	25	75	100
	III	TPBCECA	Microbiology & Immunology	Elective – I	3	5	25	75	100
	III	TPBCECB	Soft Skill	Elective – II	3	5	25	75	100
					20	30			500
II	III	T2PBCC4	Enzymology	2.1. Core- IV	5	6	25	75	100
	III	T2PBCC5	Biochemical and Molecular Biology Techniques	2.2 Core-V	5	6	25	75	100
	III	T2PBCC6	Practical II: Advanced Biochemical Techniques	2.3 Core – VI	4	6	25	75	100
	III	TPBCECC	Elective – III Energy and drug metabolism	2.4 Discipline Centric Elective – III	3	4	25	75	100
	III	TPBCECD	Elective - IV : Nutritional Biochemistry	2.5 Generic Elective - IV:	2	4	25	75	100
	IV	T2PBCS1	SEC1: Biostatistics and Data Science	SEC1	2	4	25	75	100
					22	30			600

III	III	T3PBCC7	Cellular Metabolism	3.1. Core-VII	5	6	25	75	100
	III	T3PBCC8	Molecular Biology	3.2 Core-VIII	5	6	25	75	100
	III	T3PBCC9	Clinical Biochemistry	3.3 Core – IX	5	6	25	75	100
	III	T3PBCC10	Practical III: Advanced Clinical Biochemistry	3.4 Core – X	4	6	25	75	100
	III	TPBCECE	Molecular basis of disease and therapeutic strategies	3.5 Discipline Centric Elective - V	3	3	25	75	100
	IV	T3PBCS2	Herbal Technology	3.6 NME II	2	3	25	75	100
IV	-	*Internship [Clinical Laboratory]Industrial Visit – Biotech	3.7 Internship/ Industrial Activity	2	-				
					26	30			600
IV	III	T4PBCC11	Pharmaceutical Biochemistry	4.1. Core-XI	5	6	25	75	100
	III	T4PBCC12	Biochemical Toxicology	4.2 Core-XII	5	6	25	75	100
	III	T4PBCC13	Project and viva	4.3 Project with viva voce	7	10	25	75	100
	III	TPBCECF	Bio-safety, Lab Safety and IPR	4.4 Elective - VI (Industry / Entrepreneurship) 20% Theory 80% Practical	3	4	25	75	100
	IV	T2PBCS3	Developmental Biology	4.5 Skill Enhancement course / Professional Competency Skill	2	4	25	75	100
	V	-	Industrial Visit – Pharma or Food Processing	4.6 Extension Activity	1				
									500
					91				2200

Course	T1PBCC1 - CORE PAPER I
Title of the Course:	BASICS OF BIOCHEMISTRY
Credits:	4
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 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 Graw-Hill. 5. Lubert Stryer (2010) Biochemistry,(7th ed), W.H.Freeman 6. Satyanarayan,U (2014) Biochemistry (4th ed), ArunabhaSen Books & Allied (P) Ltd, Kolkata.

Course	T1PBCC2 - CORE PAPER -II
Title of the Course:	PHYSIOLOGY AND CELL BIOLOGY
Credits:	4
Units	
I	Major classes of cell junctions- anchoring, tight and gap junctions. Major families of cell adhesion molecules (CAMs)- cadherins, integrins. Types of tissues. Epithelium- organisation and types. The basement membrane. Cell cycle- mitosis and meiosis, Cell cycle-phases and regulation. Cell death mechanisms- an overview-apoptosis, necrosis.
II	Reproductive system- sexual differentiation and development; sperm transport, sperm capacitation, semen analyses and Acrosome reaction. Clinical relevance of female reproductive physiology- menstrual cycle, pregnancy and menopause. Fertilisation and infertility issues.
III	Digestive system- structure and functions of different components of digestive system, digestion and absorption of carbohydrates, lipids and proteins, role of bile salts in digestion and absorption, mechanism of HCl formation in stomach, role of various enzymes and hormones involved in digestive system. Composition of blood, lymph and CSF. Blood cells - WBC, RBC and energy metabolism of RBC, Blood clotting mechanism and blood groups- ABO and Rhesus system.
IV	Respiratory system-Gaseous transport and acid-base homeostasis. Mechanism of the movement of 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.
VI	Hormones – Classification, Biosynthesis, circulation in blood, modification and degradation. Mechanism of hormone action, Target cell concept. Hormones of Hypothalamus, pituitary, Pancreatic, thyroid & parathyroid, adrenal and gonadal hormones. Synthesis, secretion, physiological actions and feedback regulation of synthesis.

Reading List (Print and online)	https://www.genome.gov/genetics-glossary/Cell-Cycle https://my.clevelandclinic.org/health/diseases/16083-infertility-causes https://www.webmd.com/heartburn-gerd/reflux-disease https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5760509/ https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3249628/
Self-Study	<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. 4. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. (5th ed). Sunderland, Mass. Sinauer Associates, Inc. 5. Wayne M. Baker (2008) the World of the Cell. (7th ed). Pearson Benjamin Cummings Publishing, San Francisco. Cell Biology 6. John E. Hall (2010). Guyton and Hall Textbook of Medical Physiology (12th ed), Saunders 7. Harrison’s Endocrinology by J. Larry Jameson Series: Harrison’s Specialty, 19th Edition Publisher: McGraw-Hill, Year: 2016.

Course	T1PBCC3 - CORE PAPER III
Title of the course:	PRACTICAL – I - BIOORGANIC ANALYSIS
Credits:	4
Units	
I	Biochemical studies and estimation of macromolecules 1. Isolation and estimation of glycogen from liver. 2. Isolation and estimation of DNA from animal tissue. 3. Isolation and estimation of RNA from yeast. 4. Purification of Polysaccharides –Starch and assessment of its purity
II	1. Estiation of sugar 2. Estimation of Protein 3. Estimation of DNA 4. Estiation of RNA 5. Acid and Saponification number of oil
III	Estimation of minerals 1. Estimation of calcium 2. Estimation of iron
IV	Group Experiments 1. Fractionation of sub-cellular organelles by differential centrifugation- Mitochondria and nucleus 2. Identification of the separated sub-cellular fractions using marker enzymes (any one)
Reading List (Print and Online)	1. https://www.researchgate.net/publication/313745155_Practical_Biochemistry_A_Student_Companion 2. https://doi.org/10.1186/s13020-018-0177-x 3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5368116/ 4. https://www.life.illinois.edu/biochem/455/Lab%20exercises/2Photometry/spectrophotometry.pdf
Self-Study	1. Laboratory Safety Rules, Requirements and Regulations. 2. Preparation of standard solutions and reagent
Books Recommended	1. David Plummer (2001) An Introduction to Practical Biochemistry (3rd ed) McGraw Hill Education (India) Private Ltd 2. Jayaraman, J (2011), laboratory Manual in Biochemistry, New age publishers 3. Varley H (2006) Practical Clinical Biochemistry (6th ed) , CBS Publishers 5. Prof. Sarin A. Chavhan, Prof. Sushilkumar A. Shinde (2019) A Guide to Chromatography Techniques Edition:1 6. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan. Springer (2011)

Course	TPBCECA - ELECTIVE PAPER -I
Title of the Course:	MICROBIOLOGY & IMMUNOLOGY
Credits:	3
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)	<p>https://www.ijam.co.in/index.php/ijam/article/view/1326 (Krumi (Microorganisms) in Ayurveda- a critical review)</p> <p>Virtual Lectures in Microbiology and Immunology, University of Rochester</p> <p>https://www.frontiersin.org/articles/10.3389/fphar.2020.578970/full#h9</p> <p>https://www.frontiersin.org/articles/10.3389/fmicb.2018.02151/full</p> <p>https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7559905/</p>
Self-Study	<ol style="list-style-type: none"> 1. Microbial infections and gut microbiome with relevance to <i>tridoshas</i> 2. Microbial population and pH variations in different dairy products.
Recommended Texts	<ol style="list-style-type: none"> 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

Course	T2PBCC4- CORE PAPER IV
Title of the Course:	ENZYMOLGY
Credits:	4
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	<p>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,</p>

	substrate concentration, allosteric effectors, covalent modification. Regulation of glycogen synthase and glycogen phosphorylase. Feedback inhibition-sequential, concerted, cumulative, enzyme-multiplicity with examples.
	Bi - Substrate reactions: Single Displacement reactions (SDR) (Ordered and Random bi bi mechanisms), Double Displacement reactions (DDR) (Ping pong mechanism), Examples, Cleland's representation of bisubstrate reactions, Graphical analysis (diagnostic plots) to differentiate SDR from DDR.
V	Enzyme technology: Immobilization of enzymes – methods - Reversible immobilization (Adsorption, Affinity binding), Irreversible immobilization (Covalent coupling, Entrapment and Microencapsulation, Crosslinking, Advantages and Disadvantages of each method, Properties of immobilized enzymes,. Designer enzymes- ribozymes and deoxyribozymes, abzymes, synzymes. Enzymes as therapeutic agents-therapeutic use of asparaginase and streptokinase. Application of enzymes in industry- Industrial application of rennin, lipases, lactases, invertase, pectinases, papain.
Reading List (Print and Online)	<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	<ol style="list-style-type: none"> 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

Course	T2PBCC5 - CORE PAPER V
Title of the Course:	BIOCHEMICAL AND MOLECULAR BIOLOGY TECHNIQUES
Credits:	4
Units	
I	General approaches to biochemical investigation, cell culture techniques and microscopic techniques. Organ and tissue slice technique, cell distribution and homogenization techniques, cell sorting, and cell counting, tissue Culture techniques. Cryopreservation, Biosensors- principle and applications. Principle, working and applications of light microscope, dark field, phase contrast and fluorescent microscope. Electron microscope- Principle, instrumentation of TEM and SEM, Specimen preparation and applications-shadow casting, negative staining and freeze fracturing.
II	Chromatographic Techniques: Basic principles of chromatography- adsorption and partition techniques. Chiral Chromatography and counter current Chromatography. Adsorption Chromatography – Hydroxy apatite chromatography and hydrophobic interaction Chromatography. Affinity chromatography. Gas liquid chromatography- principle, instrumentation, column development, detectors and applications. Low pressure column chromatography – principle, instrumentation, column packing, detection, quantitation and column efficiency, High pressure liquid chromatography- principle, instrumentation, delivery pump, sample injection unit, column packing, development, detection and application. Reverse HPLC, capillary electro chromatography and perfusion chromatography.
III	Electrophoretic Techniques: General principles of electrophoresis, supporting medium, factors affecting electrophoresis, Isoelectric focusing-principle, ampholyte, development of pH gradient and application. PAGE-gel casting-horizontal, vertical, slab gels, sample application, detection-staining using CBB, silver, fluorescent stains. SDS PAGE-principle and application in molecular weight determination principle of disc gel electrophoresis ,2D PAGE. Electrophoresis of nucleic acids-agarose gel electrophoresis of DNA, pulsed field gel electrophoresis-principle, apparatus, application. Electrophoresis of RNA, curve. Microchip electrophoresis and 2D electrophoresis, Capillary electrophoresis.
IV	Spectroscopic techniques: Basic laws of light absorption- principle, instrumentation and applications of UV-Visible, IR, ESR, NMR, Mass spectroscopy, Turbidimetry and Nephelometry. Luminometry (Luciferase system, chemiluminescence). X - ray diffraction. Atomic absorption spectroscopy - principle and applications - Determination of trace elements

V	<p>Radiolabeling Techniques and Centrifugation: Nature of radioactivity-detection and measurement of radioactivity, methods based upon ionisation (GM counter) and excitation (scintillation counter), autoradiography and applications of radioactive isotopes, Biological hazards of radiation and safety measures in handling radioactive isotopes.</p> <p>Basic principles of Centrifugation. Preparative ultracentrifugation - Differential centrifugation, Density gradient centrifugation. Analytical ultracentrifugation - Molecular weight determination.</p>
Reading List (Print and Online)	Principles and techniques of biochemistry and molecular biology: https://www.kau.edu.sa/Files/0017514/Subjects/principals%20and%20techniques%20of%20biochemistry%20and%20molecular%20biology%207th%20ed%
Self-Study	<ol style="list-style-type: none"> 1. Types of rotors 2. Colorimetry – principle and applications
Recommended Texts	<ol style="list-style-type: none"> 1.Keith Wilson , John Walker (2010) Principles and Techniques of Biochemistry and Molecular Biology (7th ed) Cambridge University Press 2.David Sheehan (2009), Physical Biochemistry: Principles and Applications (2nd ed), Wiley-Blackwell 3.David M. Freifelder (1982) Physical Biochemistry: Applications to Biochemistry and Molecular Biology, W.H.Freeman 4.Rodney F.Boyer (2012), Biochemistry Laboratory: Modern Theory and techniques,(2nd ed),Prentice Hall 5.Kaloch Rajan (2011), Analytical techniques in Biochemistry and Molecular Biology, Springer 6. Segel I.H (1976) Biochemical Calculations (2nd ed),John Wiley and Sons 7. Robyt JF (2015) Biochemical techniques: Theory and Practice (1st ed), CBS Publishers & Distributors

Course	T2PBCC6 - CORE PAPER VI
Title of the Course:	PRACTICAL – II: ADVANCED BIOCHEMICAL TECHNIQUES
Credits:	4
Units	
I	CHROMATOGRAPHY 1. Paper chromatography 2. TLC
II	UV absorption 1. Denaturation of DNA and absorption studies at 260nm. 2. Denaturation of Protein and absorption studies at 280nm.
III	Colorimetric estimations 1. Estimation of Pyruvate 2. Estimation of tryptophan.
IV	Estimation of minerals 1. Estimation of calcium 2. Estimation of iron
V	Plant Biochemistry 1. Qualitative analysis Phytochemical screening 2. Estimation of Flavonoids -Quantitative analysis
Reading List (Print and Online)	1. https://www.researchgate.net/publication/313745155_Practical_Biochemistry_A_Student_Companion 2. https://doi.org/10.1186/s13020-018-0177-x 3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5368116/ 4. https://www.life.illinois.edu/biochem/455/Lab%20exercises/2Photometry/spectrophotometry.pdf 5. https://ijpsr.com/bft-article/determination-of-total-flavonoid-and-phenol-content-in-mimusops-elengi-linn/?view=fulltext 6. https://skyfox.co/wp-content/uploads/2020/12/Practical-Manual-of-Biochemistry.pdf
Self-Study	1. Laboratory Safety Rules, Requirements and Regulations. 2. Preparation of standard solutions and reagent
Books Recommended	1. David Plummer (2001) An Introduction to Practical Biochemistry (3rd ed) McGraw Hill Education (India) Private Ltd 2. Jayaraman, J (2011), laboratory Manual in Biochemistry, New age publishers 3. Varley H (2006) Practical Clinical Biochemistry (6th ed) , CBS Publishers 4. O. Debiyi and F. A. Sofowora, (1978) "Phytochemical screening of medical plants," Iloyidia, vol. 3, pp. 234–246, 5. Prof. Sarin A. Chavhan, Prof. Sushilkumar A. Shinde (2019) A Guide to Chromatography Techniques Edition:1 6. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan. Springer (2011)

Course	TPBCECC - CORE ELECTIVE PAPER III
Title of the Course:	ENERGY AND DRUG METABOLISM
Credits:	3
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"> 1. https://chemed.chem.purdue.edu/genchem/topicreview/bp/ch21/gibbs.php 2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7767752/#:~:text=The%20mitochondrial%20electron%20transport%20chain,cellular%20ATP%20through%20oxidative%20phosphorylation. 3. https://www.researchgate.net/figure/Oxidative-phosphorylation-in-mitochondrial-electron-transport-chain-ETC-and-

	proton_fig1_230798915
Self-Study	<ol style="list-style-type: none"> 1. Calculation of Keq and ΔG 2. Interrelationship of carbohydrate, protein, and fat metabolism-role of acetyl CoA
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. Robert K. Murray, Darryl K. Granner, Peter A. Mayes, and Victor W. Rodwell (2012), Harper's Illustrated Biochemistry, (29th ed), McGraw-Hill Medical 3. Metzler D.E (2003). The chemical reactions of living cells (2nd ed), Academic Press. 4. Zubay G.L (1999) Biochemistry , (4th ed), Mc Graw-Hill. 5. Devlin RM (1983) Plant Physiology (4th ed), PWS publishers 6. Taiz L , Zeiger E (2010), Plant Physiology (5th ed), Sinauer Associates, Inc

Course	TPBCECD - EC-4: ELECTIVE PAPER-IV
Title of the Course:	NUTRITIONAL BIOCHEMISTRY
Credits:	3
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 Diet Therapy, 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

Course	T2PBCS1 - SEC1
Title of the Course:	BIOSTATISTICS & DATA SCIENCE
Credits:	3
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.

Course	T3PBCC7 - CORE PAPER VII
Title of the Course:	CELLULAR METABOLISM
Credits:	4
Units	
I	Glycolysis – aerobic and anaerobic, inhibitors, and regulation. Feeder pathway- entry of hexoses into glycolysis, Galactosemia, fructosuria, Pyruvate dehydrogenase complex-mechanism and regulation. Glyoxalate cycle and its regulation. Gluconeogenesis- source, key enzymes, reaction sequence and its regulation. Blood glucose homeostasis and the role of hormones. Pentose phosphate pathway-significance and its regulation. Metabolism of glycogen and its regulation. Biosynthesis of N-linked and O-linked glycoproteins, mucopolysaccharides, Chondroitin sulphate.
II	Oxidation of fatty acids-oxidation of saturated and unsaturated fatty acids (α , β & ω oxidation) Oxidation of fatty acids with odd and even numbered carbon atoms. Regulation of β oxidation. Ketogenesis and its regulation. Biosynthesis of fatty acid–saturated and unsaturated, chain elongation, regulation. Biosynthesis of prostaglandins, thromboxanes and leukotrienes and hydroxyl eicosanoic acids. Biosynthesis and degradation of triacylglycerol, phosphoglycero lipids-lecithin, cephalin, plasmalogens and phosphatidyl inositol, Sphingolipid-sphingomyelin, cerebrosides, sulfatides, and gangliosides. Cholesterol biosynthesis and its regulation. Lipoprotein metabolism-chylomicrons, VLDL, HDL and LDL.
III	Metabolism of nucleotides- <i>De novo</i> 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.
IV	Biosynthesis of non- essential amino acids.- Role and biological significance of glutamate dehydrogenase, glutamine and asparagine synthetase, lysine, proline and phenylalanine hydroxylase. Interconversion of amino acids - proline to glutamate, methionine to cysteine, serine to glycine. Biosynthesis of spermine and spermidine. Degradation of amino acids –glucogenic and ketogenic amino acids. Formation of acetate from leucine and aromatic amino acid, pyruvate from cysteine, threonine and hydroxy proline, α -keto glutarate from histidine and proline, succinate from methionine, threonine, valine and isoleucine, Oxaloacetate from aspartate, glycine and serine.

V	Biosynthesis and degradation of heme. Jaundice-classification, pathology and Differential diagnosis Oxidation and reduction of inorganic sulphur compounds by microbes and plants. Sulpho transferases and their biological role-rhodanases, sulphatases , 3-mercapto pyruvate sulphur transferases. Mucopolysaccharidoses - Hunter syndrome, Sanfilippo syndrome and Maroteaux-Lamy syndrome. Oxidation of cysteine to sulphate and inter conversion of sulphur compounds.
Reading List (Print and Online)	<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	<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. Human Biochemistry – James M. Orten & Otto.W. Neuhau- 10th edn- The C.V. Mosby Company

Course	T3PBCC8 - CORE PAPER –VIII
Title of the Course:	MOLECULAR BIOLOGY
Credits:	4
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	Transcription – Prokaryotic transcription-subunits of RNA polymerase, <i>E. coli</i> promoters, sigma factor and promoter recognition, alternative sigma factors, initiation, elongation, Rho-dependent and independent termination of transcription. Eukaryotic transcription- Initiation, promoter elements, RNA polymerases, transcription factors, regulatory sequences in eukaryotic protein – coding genes, CpG islands, enhancers. Translation – organization of the ribosome, the genetic code, evidence for a triplet code, deciphering the genetic code, wobble hypothesis, deviation in the genetic code, unusual codons. activation, initiation, elongation and termination of translation in <i>E. coli</i> . The role of tRNA and rRNA, suppressor tRNAs and inhibitors of protein synthesis., Comparison of prokaryotic translation with eukaryotic translation.

IV	Regulation of gene expression in prokaryotes— Positive and negative control, the lac operon, identification of operator and regulator sequences by mutations, induction and repression, Foot-printing and gel-shift assays for identification of protein-DNA interactions. Catabolite repression. <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	Post transcriptional modifications in eukaryotes- RNA processing- mRNA 5' capping and 3' poly-adenylation, introns and exons, RNA splicing,- spliceosome assembly, alternative splicing, processing of tRNA and rRNA, self-splicing, ribozymes, RNA editing- substitution and insertion/deletion editing, Genome editing-CRISPR- Cas technology Post translational modification of proteins- Proteolytic cleavage, covalent modifications, glycosylation of proteins, disulfide bond formation, Protein sorting – signal peptides, transport of secretory proteins, Golgi and post-golgi sorting, coated vesicles, targeting of mitochondrial, lysosomal and nuclear proteins, Protein degradation-Ubiquitination of proteins, Protein folding-chaperones
Reading List (Print and Online)	<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.

<p>Recommended Texts</p>	<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
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Course I	T3PBCC9 - CORE PAPER – IX
Title of the Course:	CLINICAL BIOCHEMISTRY
Credits:	4
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> <p>Disorders of blood cells: Hemolytic, iron deficiency and aplastic anemia and diagnosis, sickle cell anaemia, thalassemia HBA1C variants. Porphyrias, Thrombocytopenia, Causes of leucopenia, leukemia and leucocytosis. Disorders of blood clotting mechanism - Von willebrand's disease, Hemophilia A, B and C, diagnostic test for clotting disorders, D-dimer and its clinical significance</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, Microalbuminuria, eGFR.</p> <p>Point of care testing for glucose (Glucometers) and continuous glucose monitoring (CGM) : principle and its use. Major groups of anti-diabetic drugs. Diet and life style modifications</p>
III	<p>Diagnostic Enzymology: Clinically Important Enzymes and Isoenzyme as diagnostic markers: Clinical significance of AST, ALT, ALP, ACP, CK, γ-GT, amylase, pseudocholinesterase and their pattern in Myocardial infarction; Liver disease, Bone disease, Muscle disease, Cancer (tumor markers), GI tract pancreatitis); Enzymes as therapeutic agents.</p> <p>Pre- and post-natal testing: Amniocentesis, prenatal detection of inborn errors of metabolism in developing fetus- Autosomal recessive mode of inheritance- cystic fibrosis, X linked recessive inheritance-Duchenne muscular dystrophy. New born screening (NBS) for In born errors of metabolism, Tandem mass spectrometry application in NBS</p>

IV	Liver function tests: Liver function test panel, Fatty liver . Plasma protein changes in liver diseases. Hepatitis A ,B and C. Cirrhosis and fibrosis. Portal hypertension and hepatic coma.Acute phase proteins - CRP, Haptoglobins, α -fetoprotein, ferritin and transferrin and their clinical significance, Interpreting serum protein electrophoresis. Inflammatory markers (cytokines such as TNF-alpha IL6 and others)
V	<p>Renal function tests - tests for glomerular and tubular function-Acute and chronic renal failure-Glomerulonephritis, Nephrotic syndrome, uraemia-urinary calculi-Nephrocalcinosis and Nephrolithiasis-causes, pathology and symptoms. Chronic kidney disease. Dialysis-Hemodialysis and peritoneal dialysis.</p> <p>Electrolyte disorder : calcium: hypercalcemia and hypocalcemia; Calcium homoestasis in Blood; phosphate: hyperphosphatemia or hypophosphatemia; Clinical significance: Potassium: hyperkalaemia and hypokalaemia, Sodium: hyponatremia and hyponatremia; Chloride: hyperchloremia, hypochloremia</p> <p>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</p>
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>

Self-Study	<p>1. Potential sources of variability in the estimation of the analytes: Pre-analytical phase: acceptance rejection criteria in terms of haemolysis/icteric/lipemia (HIL) interferences Analytical phase: Linearity, detection limits precision, accuracy, specificity, sensitivity; Total Allowable Error. (Definitions and examples). Post-analytical phase : Units of reporting of clinical chemistry parameters-</p> <p>2. Interpretation of results in clinical chemistry based on laboratory investigations and quality control:</p> <ul style="list-style-type: none"> • critical / alert values • American Diabetes Association (ADA) Standards of Medical Care in Diabetes (yearly update); HBA1C testing :NGSP • Case studies to review • Quality control for clinical chemistry in laboratory
Recommended Texts	<ol style="list-style-type: none"> 1. ThomasM.Devlin (2014) Textbook of Biochemistry with Clinical Correlations (7th ed). John Wiley & Sons 2. Montgomery R, Conway TW, Spector AA (1996),Biochemistry: A Case-Oriented Approach (6th ed), Mosby Publishers, USA. 3. Tietz Fundamentals of Clinical Chemistry and Molecular Diagnostics (2018) (8th ed),Saunders 4. Dinesh Puri, (2020) Text book of Biochemistry: A clinically oriented approach – 4th Edition, Elsevier. 5. 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

Course	T3PBCC10 - CORE PAPER – X:PRACTICAL III
Title of the Course:	ADVANCED CLINICAL BIOCHEMISTRY
Credits:	4
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)	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.pdf https://www.westgard.com/clia.html 3. https://www.researchgate.net/publication/263929434_Biochemistry 4. https://ucms.ac.in/Lectures-C-2020/Renal%20function%20Tests%20-%20PPT.pdf 5. https://youtu.be/i2PfjEks4GQ

	6. https://www.euro.who.int/__data/assets/pdf_file/0005/268790/WHO-guidelines-on-drawing-blood-best-practices-in-phlebotomy-Eng.pdf
Self-Study	<ol style="list-style-type: none"> 1. Laboratory handling of human biological specimen 2. Automation in Clinical Biochemistry
Recommended Texts	<ol style="list-style-type: none"> 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 Hill Publishing Company, 2000. 6. Introductory practical Biochemistry – S.K. Sawhney, Randhir Singh, 2nd ed, 2005.

Course	TPBCECE - ELECTIVE COURSE V
Title of the Course:	MOLECULAR BASIS OF DISEASES AND THERAPEUTIC STRATEGIES
Credits:	3
Units	
I	Mechanism of blood sugar regulation in human body. Pathophysiology of Type I and II diabetes, Diabetes – investigation methods for the diagnosis of diabetes. Nutritional care. Complications related to diabetes – Diabetic cardiovascular disease, retinopathy, neuropathy and nephropathy. Cellular and molecular mechanism of development of diabetes- Management of Type I and Type II diabetes, drugs for the treatment of diabetes.
II	Biology of cancer: Overview of hallmarks of cancer. Tumorigenesis, Tumor progression and mechanism of Metastasis. Proto-oncogene to oncogene. Oncogene- myc and src family. Tumor suppressor gene-Rb and p53 pathway in cancer. Diagnosis- Non-invasive imaging techniques, Tumor diagnosis, Interventional radiology, New imaging technique, Molecular techniques in cancer diagnosis.- treatment of cancer- surgery, radiotherapy, chemotherapy, hormonal treatment, and biological therapy. Introduction to personalized medicine.
III	Brain- neuronal network- memory- Neurodegenerative diseases- Parkinson and Alzheimer Disease- molecular understanding of the neurodegenerative diseases- treatment modalities.
IV	Acute and chronic renal failure, glomerular diseases–glomerulonephritis, nephritic syndrome, diabetes insipidus, diagnosis of kidney disease.
V	Introduction to cardiovascular diseases, Lipids and lipoproteins in coronary heart disease-cardiac enzymes, Molecular changes during cardiac remodeling – hypertrophy of hearts – heart failure- treatment modalities.
Reading List (Print and Online)	<ol style="list-style-type: none"> 1. The Biochemical basis of disease:2018, Barr AJ; Portland Press 2. Biochemical Basis of Diseases 3. https://www.biologydiscussion.com/diseases-2/biochemical-basis-of-diseases/44276

Recommended Texts	1.Wills' Biochemical Basis of Medicine: 2 nd edition, Thomas H, Gillham B;Elsevier 2.Molecular Biochemistry of Human Diseases,2021, Feuer G ,de la Iglesia F; CRC Press
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Course I	T4PBCC11- CORE PAPER – XI
Title of the Course:	PHARMACEUTICAL BIOCHEMISTRY
Credits:	4
Units	
I	Drug discovery and development, drug target identification and validation, Hit identification, General principles of screening, correlations between various animal models and human situations, Correlation between in-vitro and in-vivo screens; Special emphasis on cell-based assay, biochemical assay, radiological binding assay, Pharmacological assay, In vitro, In vivo & Ex-vivo experiments, lead optimization, preclinical studies.
II	Bioinformatics approaches for drug development: Identification of potential molecules, chemical compound library preparation, Identification of target in pathogen, Ligand & protein preparation, Molecular docking, Binding free energy estimation, High throughput virtual screening, Docking protocol validation and enrichment analysis, Single point energy calculation, Pharmacokinetics and Pharmacodynamics, ADME & toxicity prediction, Molecular dynamic simulation, Rule of three and five, Lipinsky rule, Pharmacophore development, Quantitative structure activity relationship, 3D-QSAR, Techniques of developing a pharmacophore map covering both ligand based and receptor based approaches.
III	Drug metabolism & interactions: Drug-receptor interactions, receptor theories and drug action, Xenobiotics, xenobiotics phases (Phase-I, Phase-II and Phase-III), role of cytochrome P450 oxidases and glutathione S-transferases in drug metabolism, factors affecting drug metabolism, Enzymes as a drug target, Kinase inhibitors, ATPase inhibitors, drug protein interaction, DrugDNA interaction. Basic ligand concepts-agonist, antagonist, partial agonist, inverse agonist, efficiency and potency. Forces involved in drug-receptor complexes. Receptor classification – the four super families. Receptor binding assays- measurement of K _d , B _{max} and IC ₅₀ .
IV	Biochemical mode of action of antibiotics- penicillin and chloramphenicol, actions of alkaloids, antiviral and antimalarial substances. Biochemical mechanism of drug resistance- sulphonamides. Drug potency and drug efficacy. General principles of chemotherapy: chemotherapy of parasitic infections, fungal infections, viral diseases.

	Introduction to immunomodulators and chemotherapy of cancer.
V	Clinical trials (Phase-I, Phase-II, Phase-III and Phase-IV clinical trial). Main features of clinical trials, including methodological and organizational considerations and the principles of trial conduct and reporting. Key designs surrounding design, sample size, delivery and assessment of clinical trials.
Self-Study	<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. T. P. Kenakin. Elsevier, 1st Edition 2012.

Course I	T4PBCC12 - CORE PAPER – XII
Title of the Course:	BIOCHEMICAL TOXICOLOGY
Credits:	4
Units	
I	Fundamentals of Toxicology and dose-Response Relationships: Introduction Biomarkers Criteria of Toxicity New Technologies Evaluation of Toxicity Interactions; Dose Response; Measurement of Dose-Response; Relationships Linear Dose Response Hormesis; Hazard and Risk Assessment Duration and Frequency of Exposure and Effect
II	Factors Affecting Toxic Responses: Disposition: Absorption ,Sites of absorption, distribution, Excretion; Metabolism: types of Metabolic change phase I reactions; Phase 2 reactions; control of Metabolism, Toxication vs. Detoxication
III	Toxicity testing; Test protocol, Genetic toxicity testing & Mutagenesis assay: In vitro test systems: bacterial mutation tests-Reversion test,Ames test, Fluctuation test, and Eukaryotic mutation test. In vivo test system Mammalian mutation test-Host mediated assay and Dominant Lethal test. Biochemical basis of toxicity: Mechanism of toxicity: Disturbance of excitable membrane function, Altered Calcium homeostasis, Covalent binding to cellular macromolecules & genotoxicity, Tissue specific toxicity
IV	Toxic Responses to Foreign Compounds: Direct Toxic Action: Tissue Lesions; Mechanism and response in cellular toxicity, pharmacological, physiological and Biochemical effects; Developmental Toxicology- Teratogenesis; Immunotoxicity Genetic Toxicity; Chemical Carcinogenesis
V	Biochemical Mechanisms of Toxicity: Tissue Lesions: Liver Necrosis; kidney Damage; Lung Damage, Liver damage, Cardiac damage; Neurotoxicity; Exaggerated and Unwanted pharmacological effects; Physiological effects; Biochemical Effects: Lethal Synthesis and Incorporation, Interaction with specific Protein Receptors; Teratogenesis; Immunotoxicity; multi-Organ Toxicity
Self-Study	• Case studies to review
Reading List (Print and Online)	1. Preclinical Safety Evaluation of Biopharmaceuticals: A Science-Based Approach to Facilitating Clinical 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

Course	TPBCECF - ELECTIVE PAPER VI
Title of the Course:	BIOSAFETY, LAB SAFETY AND IPR
Credits:	3
Units	
I	Biosafety: Historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; recommended biosafety levels for infectious agents and infected animals; biosafety guidelines - government of India, roles of IBSC, RCGM, GEAC etc. for GMO applications in food and agriculture; environmental release of GMOs; risk assessment; risk management and communication; national regulations and international agreements.
II	Laboratory safety - Chemical, electrical and fire hazards; handling and manipulating human or animal cells and tissues, toxic, corrosive or mutagenic solvents and reagents; mouth pipetting, and inhalation exposures to infectious aerosols, Safe handling of syringe needles or other contaminated sharps, spills and splashes onto skin and mucous membranes. Health aspects; toxicology, allergenicity, antibiotic resistance. History of biosafety microbiology and molecular biology, Risk assessment, Personal protective equipment, Laboratory facilities and safety equipment, Disinfection, decontamination, and sterilization, Regulatory compliance, Laboratory security and emergency response and administrative controls.
III	Intellectual Property Rights (IPR): Introduction to patents, types of patents, process involved in patenting in India, trademarks, copyright, industrial design, trade secrets, traditional knowledge, geographical indications, history of national and international treaties and conventions on patents, WTO, GATT, WIPO, Budapest Treaty, Patent Cooperation Treaty (PCT) and TRIPS. Patent databases: Searching international databases; analysis and report formation. Indian Patent Act 1970; recent amendments; filing of a patent application; precautions before patenting disclosure/non-disclosure; procedure for filing a PCT application. The patentability of microorganisms-claims, Characterization and repeatability disposition in the culture collections, legal protection for plants and other higher organisms, new plant varieties by rights, tissue culture protocols

IV	Patent filing and infringement: Patent application- forms and guidelines, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and convention patent applications, International patenting-requirement, financial assistance for patenting-introduction to existing schemes; Publication of patents-gazette of India, status in Europe and US. Research Patenting: Patenting by researchers and scientists-University/organizational rules in India and abroad. Detailed information on patenting biological products, Case studies on patents (basmati rice, turmeric, neem etc.), and patent infringement.
V	Bioethics: Introduction to bioethics, human genome project and its ethical issues, genetic manipulations and their ethical issues, ethical issues in GMOs, foods and crops in developed and developing countries, environmental release of GMOs, ethical issues involved in stem cell research and use, use of animals in research experiments, animal cloning, human cloning and their ethical aspects, testing of drugs on human volunteers.
Self-Study	1. Review of drug patent documents 2. Safety in biological research laboratories
Reading List (Print and Online)	1. V. Shree Krishna, (2007). Bioethics and Biosafety in Biotechnology, New Age International Pvt. Ltd. Publishers. (Unit III, Unit IV and Unit V) 2. Deepa Goel, Shomini Parashar, (2013). IPR, Biosafety and Bioethics, Pearson. (Unit II) 3. R. Ian Freshney, 2016. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, 6th Ed, John Wiley & Blackwell. 4. BAREACT, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007. (Unit I)
Recommended Texts	1. Biosafety in Microbiological and Biomedical Laboratories, (2020) 6th Ed. (https://www.cdc.gov/labs/pdf/SF__19_308133-A_BMBL6_00-BOOK-WEB-final3.pdf) 2. Kankanala C., (2007), Genetic Patent Law & Strategy, 1st Edition, Manupatra Information Solution Pvt. Ltd.,

Course I	T2PBCS3 - SKILL ENHANCEMENT PAPER
Title of the Course:	DEVELOPMENTAL BIOLOGY
Credits:	3
Units	
I	Overview of Developmental biology: Background of Developmental biology - Principles of developmental biology –Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development.
II	Model organisms Gametogenesis – production of gametes, Formation of zygote, fertilization and early development: molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in plants;cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination. <i>Drosophila</i> Developmental biology- Axis formation, Genes & mutation. <i>C.elegans</i> – Vulva formation, Axis formation.
III	Regeneration Developmental Biology Stem cells – Definition, Classification, Embryonic and adult stem cells, properties, identification, Culture of stem cells, Differentiation and dedifferentiation, Stem cellmarkers, techniques and their applications in modern clinical sciences. Three- dimensional culture and transplantation of engineered cells. Tissue engineering - skin, bone and neuronal tissues.
IV	Morphogenesis & Organogenesis:Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in <i>Drosophila</i> , amphibia and chick; organogenesis – vulva formation in <i>Caenorhabditis elegans</i> , eye lens formation, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.
V	Cellular senescence and Cell fate decision Cellular senescence – concepts & Frizzled receptor in Development and disease. Diabetes and developmental biology, Cell death pathways in developments. Markers of important diseases.
Reading List (Print and Online)	Developmental Biology – Gilbert Scott http://bgc.org.in/pdf/study-material/developmental-biology-7th-ed-sf-gilbert.pdf
Recommended Texts	Developmental biology: VIII edition, Gilbert, SF ; Sinauer Associates, Inc