ANNAMALAI UNIVERSITY
(Affiliated Colleges)
408 - M.Sc. Biochemistry
Programme Structure and Scheme of Examination (under CBCS)
(Applicable to the candidates admitted from the academic year 2023 -2024 onwards)

Elective – IV:

Part	Course Code	Study Components & Course Title	Credit	Hours/ Week	Maximum Marks		
					CIA	ESE	Total
		SEMESTER – I					
A	23PBIOC11	**Core - I:** Basics of Biochemistry.	5	7	25	75	100
	23PBIOC12	**Core - II:** Biochemical and Molecular Biology Techniques	5	7	25	75	100
	23PBIOP13	**Core - III:** Practical I: Laboratory course on Biomolecules and Biochemical Techniques	4	6	25	75	100
	23PBIOE14-1	**Elective – I:** Physiology & Cell Biology (To include Hormones)	3	5	25	75	100
	23PBIOE14-2	Developmental Biology					
	23PBIOE15-1	**Elective-II:** Microbiology and Immunology (or)	3	5	25	75	100
	23PBIOE15-2	Plant Biochemistry					
		Total	**20**	**30**			**500**
		SEMESTER – II					
A	23PBIOC21	**Core - IV:** Enzymology	5	6	25	75	100
	23PBIOC22	**Core - V:** Cellular Metabolism	5	6	25	75	100
	23PBIOP23	**Core - VI:** Practical II: Laboratory course on Enzymology, Cell Biology and Microbiology	4	6	25	75	100
	23PBIOE24-1 23PBIOE24-2	**Elective – III:** Clinical Biochemistry (or) Research Methodology	3	4	25	75	100
	23PBIOE25-1 23PBIOE25-2	**Elective – IV:** Energy and drug metabolism (or) Bioinformatics	3	4	25	75	100
B (i)	23PBIOS26	**Skill Enhancement Course (SEC-I):** Organic farming	2	4	25	75	100
		Total	**22**	**30**			**600**
		SEMESTER – III					
A	23PBIOC31	**Core - VII:** Industrial Microbiology	5	6	25	75	100
	23PBIOC32	**Core - VIII:** Molecular Biology	5	6	25	75	100
	23PBIOC33	**Core – IX :** Gene Editing, Cell and Gene therapy	5	6	25	75	100
	23PBIOC34	**Core – X:** Biostatistics and Data Science	4	6	25	75	100
	23PBIOE35	**Elective–V:** Molecular basis of disease and therapeutic strategies	3	3	25	75	100

B(i)	23PBIOS36	**Skill Enhancement Course (SEC-II):** Laboratory Course on Clinical Biochemistry (Practical)	2	3	25	75	100
B(ii)	23PBIOI37	**Summer Internship ***	2	-	25	75	100
		Total	**26**	**30**			**700**
		SEMESTER – IV					
A	23PBIOC41	**Core - XI:** Pharmaceutical Biochemistry	5	6	25	75	100
	23PBIOC42	**Core - XII:** Biochemical Toxicology	5	6	25	75	100
	23PBIOD43	Project with Viva-Voce	7	10	25	75	100
	23PBIOE44	**Elective – VI:** Industry or Entrepreneurship [20% Theory + 80% Practical] ** Bio-safety, Lab Safety and IPR	3	4	25	75	100
B(i)	23PBIOS45	**Skill Enhancement Course (SEC-III):** Developmental Biology	2	4	25	75	100
C	23PBIOX46	Extension Activity Industrial Visit – Pharma or Food Processing	1	-	100	-	100
		Total	**23**	**30**			**600**

* Students should complete two weeks of internship before the commencement of III semester.

** Evaluation is to be done both for theory (15 marks) and practical (60 marks) components separately by the examiners who will be conducting the practical and the marks should be awarded out of 75. Questions for the theory and practical are to be set by the concerned examiners.

Credit Distribution

Study Components	**Papers**	**Total Credits**	**Marks/Sub**	**Total Marks**
Core theory	10	49	100	1000
Core Electives	6	18	100	600
Core Practical	2	8	100	200
Skill Enhancement Courses SEC1, SEC2, SEC3	3	6	100	300
Internship/Industrial Activity (Carried out in Summer Vacation at the end of I Year – Two Weeks Period)	1	2	100	100
Project	1	7	100	100
Extension Activity	1	1	100	100
	24	**91**		**2400**

Credit Distribution for PG Science Programme

Part	Course Details	No. of courses	Credit per course	Total Credit
A	Core Theory	10	4-5	**49**
	Core Practical	2	4	**8**
	Elective Course	6	3	**18**
	Project Work with VIVA-VOCE	1	7	**7**
B(i)	Skill Enhancement Course	3	2	**6**
B(ii)	Summer Internship/ Industrial Activity	1	2	**2**
C	Extension Activity	1	1	**1**
		24		**91**

Component-wise Credit Distribution

Part	Courses	Sem I	Sem II	Sem III	Sem IV	Total
A	Core (including Practical and Project)	14	14	19	17	**64**
	Elective	6	6	3	3	**18**
B(i)	Skill Enhancement Course	-	2	2	2	**6**
B(ii)	Summer Internship/Industrial Activity	-	-	2	-	**2**
C	Extension Activity	-	-	-	1	**1**
						91

Part A and B(i) component will be taken into account for CGPA calculation for the post graduate programme and the other components Part B(ii) and C have to be completed during the duration of the programme as per the norms, to be eligible for obtaining PG degree.

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

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

Semester	23PBIOC11: CORE COURSE - I	H/W	C
I	CORE COURSE-I- BASICS OF BIOCHEMISTRY	7	5

Pre-requisites, if any:	Basic Knowledge of Biochemistry and Biomolecules
Course Objectives	The main objectives of this course are to: **1.** Students will be introduced to the structure of biomolecules. **2.** The significance of carbohydrates in biologicalprocesses 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 theirbiological significance. **5.** Students will gain knowledge about the structures and functional roles of nucleic acids in the biological system
Course Outcomes	On successful completion of the course, the students should be able to: **CO1 :** Explain the chemical structure and functions of carbohydrates.(K1, K2) **CO2:** Using the knowledge of lipid structure and function, explain how it plays a role inSignalling pathways (K3,K4) **CO3:** Describe the various levels of structural organisation of proteins and the role of proteins in biological system (K4, K5) **CO4:** Apply the knowledge of proteins in cell-cellinteractions.(K3,K4) **CO5.** Applying the knowledge of nucleic acid sequencing in research and diagnosis (K2, K3,K4)

Units	
I	Carbohydrates- Classification, structure (configurations and conformations, anomeric forms), function and properties of monosaccharides, mutarotation, Disaccharides and oligosaccharides with suitable examples . Polysaccharides - Homopolysaccharides (starch, glycogen, cellulose, inulin, dextrin, agar, pectin, dextran). Heteropolysaccharides - Glycosaminoglycans– source, structure, functions of hyaluronic acid, chondroitin sulphates, heparin, keratan sulphate,. Glycoproteins - proteoglycans. O- Linked and N-linked glycoproteins. Biological significance of glycan. Blood group polysaccharides. Bacterial cell wall (peptidoglycans, teichoic acid) and plant cell wall carbohydrates.

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 Amino acids - 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)	1. https://bio.libretexts.org/Bookshelves/Biochemistry/Book%3A_Biochemistry_Online_(Jakubowski) 2. https://www.thermofisher.com/in/en/home/life-science/protein-biology/protein-biology-learning-center/protein-biology-resource-library/pierce-protein-methods/protein-glycosylation.html 3. https://ocw.mit.edu/courses/biology/7-88j-protein-folding-and- human-disease-spring-2015/study-materials/ 4. https://www.open.edu/openlearn/science-maths-technology/science/biology/nucleic-acids-and-chromatin/content-section-3.4.2 5. https://www.genome.gov/genetics-glossary/Cell-Membrane https://nptel.ac.in/content/storage2/courses/102103012/pdf/mod3.pdf

Self-Study	1. Classification of Sugars 2. Nutritional classifcation of fatty acids
Recommended Texts	1. David L.Nelson and Michael M.Cox (2012) LehningerPrinciples 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
10	10	5	75	100

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

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

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

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

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

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

Mapping with Programme Outcomes:

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

Strong: Medium: Low

Semester	23PBIOC12: CORE COURSE - II	H/W	C
I	BIOCHEMICAL AND MOLECULAR BIOLOGY TECHNIQUES	7	5

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

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

Method of Evaluation:

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

Methods of assessment:

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

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

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

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

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

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

Mapping with Programme Outcomes:

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

Semester	23PBIOC13: CORE COURSE - III Practical -1	H/W	C
I	LABORATORY COURSE ON BIOMOLECULES AND BIOCHEMICAL TECHNIQUES	6	4

Pre-requisites	Knowledge on basic principles, Instrumentation of Biochemical techniques and metabolic reactions
Course Objectives	1. To instill skill in students enabling them to apprehend the wider knowledge about principles and techniques to be employed for the biomolecules under investigation. 2.To inculcate the knowledge of various isolation and purification techniques of macromolecules like DNA, RNA, Glycogen and Starch, 3. To perform colorimetric estimations to quantify important metabolites like lactate and tryptophan and minerals like calcium and iron from various sources. 4. To achieve training in subcellular fractionation and to identify them by markers. 5 To achieve training in various chromatographic techniques. 6. To perform the isolation and identification of the organelles of a cell using differential centrifugation. 7. To perform phytochemical screening and quantification enabling them to give an insight on phytochemicals this will be useful for future research.
Course Outcomes	**On successful completion of this course, students should be able to:** After completion of the course, the students should be able to: **CO1.**The student will be able to acquire knowledge and skill in the techniques used in the isolation, purification and estimation of different biomolecules that are widely employed in research (K1, K2, K4) **CO2.**The students will get acquainted with Principle, Instrumentation and method of Performing UV absorption studies of DNA, Protein and interpreting the alteration occurred during the process of denaturation (K1,K2, K 3, K4).

	CO3. The student will be fine-tune in handling the instruments like colorimeter, spectrophotometer and will be able to estimate the biomolecules and minerals from the given samples (K1,K2,K4,) **CO4.** The student, in addition to acquiring skill in performing various biochemical techniques can also learn to detect presence of phytochemicals and quantify them in the plant sample. (K1,K2,K3,K4 & K6) **CO5.**The students will develop skill in analytical techniques like subcellular fractionation, Paper, Column and Thin layer Chromatography and the group experiments will enable them to build learning skills like team work, Problem solving, Communication ability. (K1, K2,K3,K4 & K6)
Units	
I	Biochemical studies and estimation of macromolecules 1. Isolation and estimation of glycogen from liver. 2. Isolation and estimation of DNA from animal tissue. 3. Isolation and estimation of RNA from yeast. 4. Purification of Polysaccharides –Starch and assessment of its purity
II	UV absorption 1. Denaturation of DNA and absorption studies at 260nm. 2. Denaturation of Protein and absorption studies at 280nm.
III	Colorimetric estimations 1. Estimation of Pyruvate 2. Estimation of tryptophan.
IV	Estimation of minerals 1. Estimation of calcium 2. Estimation of iron
V	Plant Biochemistry 1. Qualitative analysis Phytochemical screening 2.Estimation of Flavonoids -Quantitative analysis
VI	Group Experiments 1.Fractionation of sub-cellular organelles by differential centrifugation-Mitochondria and nucleus 2. Identification of the separated sub-cellular fractions using marker enzymes (any one) 3.Separation of identification of lipids by thin layer chromatography.. 4.Separation of plant pigments from leaves by column chromatography 5. Identification of Sugars by Paper Chromatography 6.Identification of Amino acids by Paper Chromatography

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

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

Method of Evaluation:

Methods of assessment:

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

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

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

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

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

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

Mapping with Programme Outcomes:

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

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

S-Strong M-Medium L-Low

Semester	23PBIOE14-1: Elective – 1 (Discipline centric)	H/W	C
I	PHYSIOLOGY AND CELL BIOLOGY (TO include Hormones)	5	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	After completion of the course, the students should be able to: **CO1.** specifically understand the biological and chemical processes within a human cell (K1, K2, K5, K6) **CO2.** identify and prevent diseases (K2, K3, K4, k5, K6) **CO3.** understand defects in digestion, nutritional deficiencies and intolerances, and gastrointestinal pathologies (K1, K2, K3, K4, K5, K6) **CO4.** identify general characteristics in individuals with imbalances of acid-base, fluid and electrolytes.(K1 , K2 , K3 , K4, K5, K6) **CO5.** process the mechanism: the transmission of biochemical information between cell membrane and nucleus. (K1, K2, K5)
Units	
I	Major classes of cell junctions- anchoring, tight and gap junctions. Major families of cell adhesion molecules (CAMs)- cadherins, integrins. Types of tissues. Epithelium- organisation and types. The basement membrane. Cell cycle- mitosis and meiosis, Cell cycle-phases and regulation. Cell death mechanisms- an overview-apoptosis, necrosis.
II	Reproductive system- sexual differentiation and development; sperm transport, sperm capacitation, semen analyses and Acrosome reaction. Clinical relevance of female reproductive physiology- menstrual cycle, pregnancy and menopause. Fertilisation and infertility issues.
III	Digestive system- structure and functions of different components of digestive system, digestion and absorption of carbohydrates, lipids and proteins, role of bile salts in digestion and absorption, mechanism of HCl formation in stomach, role of various enzymes and hormones involved in digestive system. Composition of blood, lymph and CSF. Blood cells - WBC, RBC and energy metabolism of RBC, Blood clotting mechanism and blood groups- ABO and Rhesus system.
IV	Respiratory system-Gaseous transport and acid-base homeostasis. Mechanism of the movement of O2 and CO2 through lungs, arterial and venous circulation. Bohr effect, oxygen and carbon dioxide binding haemoglobin. pH maintenance

	by cellular and intracellular proteins. Phosphate and bicarbonate buffers, Metabolic acidosis and alkalosis. Respiratory acidosis and alkalosis. Regulation of fluid and electrolyte balance.
V	Sensory transduction, Nerve impulse transmission- nerve cells, synapses, reflex arc structure, resting membrane potential, Nernst equation, action potential, voltage gated ion-channels, impulse transmission, neurotransmission, neurotransmitter receptors, synaptosomes, synaptotagmin, rod and cone cells in the retina, changes in the visual cycle, photochemical reaction and regulation of rhodopsin, odour receptors, learning and memory. Chemistry of muscle contraction – actin and myosin filaments, theories involved in muscle contraction, mechanism of muscle contraction, energy sources for muscle contraction.
VI	Hormones – Classification, Biosynthesis, circulation in blood, modification and degradation. Mechanism of hormone action, Target cell concept. Hormones of Hypothalamus, pituitary, Pancreatic, thyroid & parathyroid, adrenal and gonadal hormones. Synthesis, secretion, physiological actions and feedback regulation of synthesis.
Reading List (Print and online)	https://www.genome.gov/genetics-glossary/Cell-Cycle https://my.clevelandclinic.org/health/diseases/16083-infertility-causes https://www.webmd.com/heartburn-gerd/reflux-disease https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5760509/ https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3249628/
Self-Study	1. Variation in cell differentiation and progression 2. Lesch Nyhan syndrome , orotic aciduria and GERD
Recommended Texts	1. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments (6th ed). John Wiley & Sons. Inc. 2. Bruce Alberts and Dennis Bray (2013),Essential Cell Biology,(4th ed),Garland Science. 3. De Robertis, E.D.P. and De Robertis, E.M.F. (2010). Cell and Molecular Biology.(8th ed). Lippincott Williams and Wilkins, Philadelphia. 4. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. (5th ed). Sunderland, Mass. Sinauer Associates, Inc. 5. Wayne M. Baker (2008) the World of the Cell. (7th ed). Pearson Benjamin Cummings Publishing, San Francisco. Cell Biology 6. John E. Hall (2010). Guyton and Hall Textbook of Medical Physiology (12th ed), Saunders 7. Harrison's Endocrinology by J. Larry Jameson Series: Harrison's Specialty, 19th Edition Publisher: McGraw-Hill, Year: 2016.

Method of Evaluation:

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

Methods of assessment:

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

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

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

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

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

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

Mapping with Programme Outcomes:

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

S-Strong M-Medium L-Low

Semester	23PBIOE14-2: Elective – 1 (Discipline centric)	H/W	C
I	DEVELOPMENTAL BIOLOGY	5	3

Course Objectives	1. Able to list the types of characteristics that make an organism ideal for the study of developmental biology (K1) 2. Know the broad phylogenetic relationships of animal phyla and some of the traits used to support our current understanding of these evolutionary relationships 3. Familiarize with the events that lead up to and comprise the process of fertilization 4. Able to draw the first four rounds of cell division of the sea urchin embryo &Understand how the planes of cell division relate to cell fate specification. 5. Develop a critical appreciation of methodologies specifically used to study the process of embryonic development in animals
Course Outcomes	After completion of the course, the students should be able to: **CO1.** Acquire Knowledge about the Developmental Biology of Frog and Chick **CO2.** Impart Basic Knowledge about the process of fertilization **CO3.** Provide a broad, comprehensive look at embryology with special emphasis on vertebrate model **CO4.** Identify the cellular behaviors that lead to morphological change during developmen **CO5.** Gain knowledge on the basis of development and regeneration of the animal body, and molecular mechanisms regulating developmental processe
Units	
I	Basic concepts of development : 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	Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in plants; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination.
III	Morphogenesis and organogenesis in animals Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila, amphibia and chick; organogenesis – vulva formation in Caenorhabditis elegans, eye lens induction, limb development and regeneration in vertebrates;

	differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.
IV	Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in Arabidopsis and Antirrhinum
V	Programmed cell death, aging and senescence
Reading List (Print and online)	•Website: virtual embryo- http://people.ucalgary.ca/~browder/virtualembryo/dev_biol.html https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5760509/ https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3249628/
Self-Study	Gametogenesis, fertilization and early development
Recommended Texts	1. Sastry K.V. (2017). Endocrinology and Reproductive biology. Rastogi publications. 2. Sembulingam. K and PremaSembulingam. (2009). Essentials of Medical Physiology. Jaypee Brothers. New Delhi. 2nd ed., 3. Laura Nuño de la Rosa, Gerd B Müller .(2021). Evolutionary Developmental Biology – A Reference Guide. Springer Reference. 4. Bob B. Buchanan, Wilhelm Gruissem, Russell L. Jones (2015). Biochemistry and Molecular Biology of Plant. 2nd Ed. 5. Gerd B. Müller (2013). Origination of Organismal Form. MIT Press Supplementary Readings 1. Richard. E. Jones., Kristin H. Lopez. (2016). Human reproductive biology. 3 rd ed., 6. C.C. Chatterjea (Vol I & Vol II). (2006). Human Physiology. Medical Allied Agency. 11th ed., 3. Benjamin Pierce (2016).Genetics: A Conceptual Approach. 6th Ed

Method of Evaluation:

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

Methods of assessment:

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

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

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

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

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

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

Mapping with Programme Outcomes:

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

Semester	23PBIOE15-1: Elective – II (Discipline centric)	H/W	C
I	MICROBIOLOGY & IMMUNOLOGY	5	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	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	After completion of the course, the students should be able to: **CO1.** To classify (by both ancient and modern modes) different types of microorganisms and explain life cycle of the microbes (K1, K2 & K5) **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) **CO3.** To understand the common pathogenic bacterial and fungi that cause toxic effects and also will be able to employ curative measures. (K1 & K2) **CO4.** To 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) **CO5.** To apply knowledge gained in production of industrially important products as both pharmaceutical and nutraceutical. (K2, K4 & K5)
Units	
I	Taxonomical classification - bacteria, viruses (DNA, RNA), algae, fungi and protozoa. Distribution and role of microorganisms in soil, water and air. Charaka's classification of microbes, lytic cycle and lysogeny. Types of culture media, isolation of pure culture, growth curve and the measurement of microbial growth.

II	Contamination and spoilage of foods – cereals, cereal products, fruits, vegetables, meat, fish, poultry, eggs, milk and milk products. General principles of traditional and modern methods of food preservation - Removal or inactivation of microorganisms, boiling, steaming, curing, pasteurization, cold processing, freeze drying, irradiation, vacuum packing, control of oxygen and enzymes. Microbes involved in preparation of fermented foods - cheese, yoghurt, curd, pickles, rice pan cake, appam, ragi porridge (கேழ்வரகு கூழ்) and bread.
III	Food poisoning- bacterial food poisoning, *Salmonella*, *Clostridium blotulinum* (botulism), *Staphylococcus aureus*, fungal food poisoning – aflatoxin, food infection – *Clostridium*, *Staphylococcus* and *Salmonella*. Pathogenic microorganisms, *E. coli, Pseudomonas, Klebsilla, Streptococcus, Haemophilus, & Mycobacterium*, causes, control, prevention, 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 *tridoshas* 2. Microbial population and pH variations in different dairy products.

Recommended Texts	1. Michael J.Pelczar Jr.(2001) Microbiology (5th ed), McGraw Hill Education (India) Private Limited 2. Frazier WC , Westhoff DC, Vanitha NM (2010) Food Microbiology (5th ed), McGraw Hill Education (India) Private Limited 3. Willey J and Sherwood L (2011) ,Prescott's Microbiology (8th ed) McGraw Hill Education (India) 4. Ananthanarayanan , Paniker and Arti Kapil (2013) Textbook of Microbiology (9th ed) 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

Semester	23PBIOE15-2: Elective – II (Discipline centric) PLANT BIOCHEMISTRY	H/W	C
I		5	3

Pre-requisites, if any:	The student should possess basic knowledge about
Course Objectives	. 1. This course presents an Introduction and provides a comprehensive, balanced introduction to this exciting, evolving and multi-disciplinary field. 2. To enable the students to learn or to know the aspects of photosynthesis. 3. To understand the concept of Nitrogen fixation process and interaction between assimilation and metabolism. 4. To understand the plant metabolism, nutrient absorption and its deficiency. 5. To be aware of various plant hormones and its roles. 6. To identify the process of Dormancy- Germination, Reproduction and budding process.
Course Outcomes	After completion of the course, the students should be able to: **CO1.** Able to gain knowledge about the different components of plant cells apart from mechanism of absorption by plants. **CO2.** To get in-depth knowledge about the functions and mechanisms of different plant hormones. **CO3.** To acquire knowledge about the steps and mechanisms involved in photosynthesis of plants. **CO4.** To know and interpret the different secondary metabolites present in the plants and its stress adaptation. **CO5.** (K2, K4 & K5) - To gain thorough understanding about the nitrogen fixing mechanisms adopted by the soil microbes.
Units	
I	Structure of plant cell – cell wall, plasmadesmata, meristematic cells, and secretary systems. Mechanism of absorption .Ion exchange passive absorption. Active absorption .The carrier concept. Donnan's equilibrium.
II	Structure, biosynthesis, mode of action &physiological effects of auxins, giberellins, cytokinins and IAA. Biochemistry of seed dormancy, seed germination,fruit ripening and senescence.
III	Structure & synthesis of chlorophyll, phycobilins and carotenoids. Photosynthesis photosystem I &II-Lightabsorption, Hill reaction, Red drop & Emerson's enhancementeffect.Cyclicand noncyclic photophosphorylation, Calvincycle.Photosynthesis-factors and regulation. Chloroplast ATP synthase, complexes

	associated with thylakoid membranes, light harvesting complexes. C3, C4 pathway and CAM
IV	Secondary metabolites in plants - classification & function of alkaloids, terpenoids, tannins, polyphenols, flavanoids, saponins, lignin and pectin.Stress metabolism in plants - Environmental stresses, salinity, water stress, heat, chilling and their impact on plant growth. Heavy metals, radiations and their impact on plant growth, criteria of stress tolerance.
V	Nitrogen fixing organisms: Structure and mechanism of action of nitrogenase: Rhizobium symbiosis. Leghaemoglobin; strategies for protection of nitrogenase against the inhibitory effect of oxygen; nif genes of klebsiella pnemoniae including their regulation. Nitrate Assimilation: Nitrate reductase; regulation of nitrate assimilation. Ammonia assimilation by glutamine synthetase- glutamine oxoglutarate amino transferase (GS-GOGAT).Nitrite and nitrate reductase
Reading List (Print and Online)	1.https://www.britannica.com/science/photosynthesis 2.http://www.biologydiscussion.com/photosynthesis/hatch-slack-c4-pathway-of-co2-fixation/51623 3.https://biodifferences.com/difference-between-photosystem-i-and-photosystem-ii.html 4. https://www.britannica.com/science/nitrogen-fixation
Self-Study	Role of photorespiration in plants. Photoperiodism and vernalization – flower induction, initiation and development, action of phytohormones
Recommended Texts	1. Heldt,H.W. 2004. Plant Biochemistry, 3rd Edition, Academic Press. 2. Srivastava, H.S. (2006), Plant Physiology, Biochemistry and Biotechnology,Rastogi Publications, Meerut. 3. A Textbook of Plant Physiology, Biochemistry and Biotechnology" by S K Verma and Mohit Verma 4.Srivastava, H.S. (2006), Plant Physiology, Biochemistry and Biotechnology,Rastogi Publications, Meerut. 5. A Textbook of Plant Physiology, Biochemistry and Biotechnology" by S K Verma and Mohit Verma Reference Book

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

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

Mapping with Programme Outcomes:

S-Strong M-Medium L-Low

Semester	23PBIOC21 : CORE PAPER IV ENZYMOLOGY	H/W	C
II		6	5

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

Units	
I	Introduction to enzymes and features of catalysis: A short history of the discovery of enzymes and how they became powerful biochemical tools. Holoenzyme, apoenzyme, cofactors, coenzyme, prosthetic groups, Classification and Nomenclature, Specificity of enzyme action-group specificity, absolute specificity, substrate specificity, stereochemical

	specificity. Active site, Identification of amino acids at the active site-trapping of ES complex, identification using chemical modification of amino acid side chains and by site-directed mutagenesis. Mechanisms of enzyme catalysis: acid-base catalysis, covalent catalysis, electrostatic catalysis, metal ion catalysis, proximity and orientation effects, Low barrier H-bonds, Structural flexibility Mechanism of action of chymotrypsin
II	Enzyme techniques: Isolation and purification of enzymes - Importance of enzyme purification, methods of purification- choice of source , extraction, fractionation methods-based on size or mass (centrifugation, gel filtration); based on polarity (ion-exchange chromatography, electrophoresis, isoelectric focusing, hydrophobic interaction chromatography); based on solubility (change in pH, change in ionic strength); based on specific binding sites (affinity chromatography) ,choice of methods, Criteria of purity of enzymes. Enzyme units - Katal, IU. Measurement of enzyme activity - discontinuous, continuous, coupled assays; stopped flow method and its applications. Isoenzymes and their separation by electrophoresis with special reference to LDH
III	Enzyme kinetics I: Thermodynamics of enzyme action, Activation energy, transition-state theory, steady-state kinetics & pre-steady-state kinetics.Single substrate enzyme catalyzed reactions -assumptions, Michaelis-Menten and Briggs-Haldane kinetics, derivation of Michaelis-Menten equation . Double reciprocal (Lineweaver-Burk) and single reciprocal (Eadie -Hofstee) linear plots, their advantages and limitations. Analysis of kinetic data- determination of Km, Vmax, kcat, and their physiological significance, Importance of kcat/Km. Enzyme inhibition: Irreversible inhibition. Reversible inhibition-Competitive, uncompetitive ,noncompetitive, mixed and substrate inhibition. Michaelis -Menten equation in the presence of competitive, uncompetitive and non-competitive inhibitors. Graphical analysis - Diagnostic plots for the determination of inhibition type. Therapeutic use of enzyme inhibitors-Aspirin, statins (irreversible inhibitors), Methotrexate (competitive inhibitor), Etoposide (non-competitive inhibitor), camptothecin (uncompetitive inhibitor). Demonstration :Using Microsoft Excel to Plot and Analyze Kinetic Data
IV	Enzyme kinetics II: Allosteric enzymes: Cooperativity, MWC and KNF models of allosteric enzymes, Sigmoidal kinetics taking ATCase as an example. Regulation of amount and catalytic activity by - extracellular signal, transcription, stability of mRNA, rate of translation and degradation, compartmentation, pH, temperature, substrate concentration, allosteric effectors, covalent modification. Regulation of glycogen synthase and glycogen phosphorylase. Feedback inhibition-sequential, concerted, cumulative, enzyme-multiplicity with examples.
	Bi - Substrate reactions: Single Displacement reactions (SDR) (Ordered and Random bi bi mechanisms), Double Displacement reactions (DDR) (Ping pong mechanism), Examples, Cleland's representation of bisubstrate reactions, Graphical analysis (diagnostic plots) to differentiate SDR from DDR.

V	Enzyme technology: Immobilization of enzymes – methods - Reversible immobilization (Adsorption, Affinity binding), Irreversible immobilization (Covalent coupling, Entrapment and Microencapsulation, Crosslinking, Advantages and Disadvantages of each method, Properties of immobilized enzymes,. Designer enzymes- ribozymes and deoxyribozymes, abzymes, synzymes. Enzymes as therapeutic agents-therapeutic use of asparaginase and streptokinase. Application of enzymes in industry- Industrial application of rennin, lipases, lactases, invertase, pectinases, papain.
Reading List (Print and Online)	**Enzymes** | MIT OpenCourseWare | Free Online Course Materials https://ocw.mit.edu/high-school/biology/exam-prep/chemistry-of-life/enzymes/ **Enzymology** https://onlinecourses.swayam2.ac.in/cec20_bt20/preview https://mooc.es/course/enzymology/ **The active site of enzymes** https://dth.ac.in/medical/courses/biochemistry/block-1/1/index.php **Enzymes and Enzyme Kinetics** https://www.lecturio.com/medical-courses/enzymes-and-enzyme kinetics.course#/ Mechanistic enzymology in drug discovery: a fresh perspective https://www.nature.com/articles/nrd.2017.219 Enzyme Biosensors for Biomedical Applications: Strategies for Safeguarding Analytical Performances in Biological Fluids https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4934206/
Self-Study	1.Mechanistic enzymology in drug discovery 2. Enzyme Biosensors for Biomedical Applications
Recommended Texts	1.Enzymes: Biochemistry, Biotechnology and Clinical chemistry, 2nd edition, 2007, Palmer T and Bonner P; Affiliated- East West press private Ltd, New Delhi 2.Fundamentals of Enzymology, 3rd edition, 2003, Price NC and Stevens L; Oxford University Press, New York 3.Voet's Biochemistry, Adapted ed, 2011,Voet,D and Voet JG; Wiley, India 4.Lehninger Principles of Biochemistry, 8th edition, 2021, .Nelson DL and Cox MM; WH Freeman & Co, New York 5. Biochemistry, Berg JM, Stryer L, Gatto,G, 8th ed, 2015;WH Freeman & Co., New York. 6.Enzyme Kinetics and Mechanism; Cook PF, Cleland W, ;2007; Garland Science, London

Method of Evaluation:

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

Methods of assessment:

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

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

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

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

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

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

Mapping with Programme Outcomes:

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

S-Strong M-Medium L-Low

Semester	23PBIOC22 : CORE PAPER V CELLULAR METABOLISM	H/W	C
II		6	5

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

II	Oxidation of fatty acids-oxidation of saturated and unsaturated fatty acids (α, β & ω oxidation) Oxidation of fatty acids with odd and even numbered carbon atoms. Regulation of β oxidation. Ketogenesis and its regulation. Biosynthesis of fatty acid–saturated and unsaturated, chain elongation, regulation. Biosynthesis of prostaglandins, thromboxanes and leukotrienes and hydroxyl eicosanoic acids. Biosynthesis and degradation of triacylglycerol, phosphoglycero lipids-lecithin, cephalin, plasmalogens and phosphatidyl inositol, Sphingolipid-sphingomyelin, cerebrosides, sulfatides, and gangliosides. Cholesterol biosynthesis and its regulation. Lipoprotein metabolism-chylomicrons, VLDL, HDL and LDL.
III	Metabolism of nucleotides- *De novo* synthesis and salvage pathways of purine and pyrimidine nucleotides. Regulation and inhibitors of nucleotide biosynthesis. Role of 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)	1. https://www.embopress.org/doi/full/10.1038/msb.2013.19 2. https://people.wou.edu/~guralnl/450Glycogen%20metabolism.pdf 3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3243375/ 4. https://www.researchgate.net/publication/334458898_Urea_Cycle 5.https://www.researchgate.net/publication/51233381_Heme_biosynthesis_and_its_regulation_Towards_understanding_and_improvement_of_heme_biosynthesis_in_filamentous_fungi 6.https://www.researchgate.net/publication/349746691_Microbial_Sulfur_Metabolism_and_Environmental_Implications

Self-study	1. Cori's Cycle and Glucose- Alanine Cycle 2. Coenzymes involved in Methanogenesis
Books Recommended	1.David L.Nelson and Michael M.Cox (2012) Lehninger Principles of Biochemistry (6th ed), W.H.Freeman 2.Voet.D and Voet. J.G (2010) Biochemistry , (4th ed), John Wiley & Sons, Inc. 3.Metzler D.E (2003). The chemical reactions of living cells (2nd ed), Academic Press. 4. Zubay G.L (1999) Biochemistry , (4th ed), Mc Grew-Hill. 5. Textbook of Biochemistry with Clinical Correlations, 7th Edition,Thomas M. Devlin (Editor), Wiley 6. Human Biochemistry – James M.Orten & Otto.W.Neuhan- 10th edn- The C.V.Mosby Company

Method of Evaluation:

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

Methods of assessment:

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

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

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

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

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

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

Mapping with Programme Outcomes:

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

S-Strong M-Medium L-Low

Semester	23PBIOP23 : CORE PAPER VI	H/W	C
II	LAB COURSE IN ENZYMOLOGY , CELL BIOLOGY AND MICROBIOLOGY	6	4

Pre-requisites	Knowledge on basic principles, Instrumentation of Biochemical techniques and metabolic reactions
Course Objectives	1. To inculcate skill in students enabling them to apprehend the 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 actualneed of the industry and various opportunities available
Course Outcomes	**On successful completion of this course, students should be able to:** After completion of the course, the students should be able to: **CO1.**The student will be able to 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) **CO2.** Student will acquire ability in performing enzyme assay, and explicate the methods that form the basis of enzyme characterization. (K1,K2,K4) **CO3.** Learn the Basic concepts in microbiology and cell biology which will be helpful for interdisciplinary research work. (K1,K3,K4) **CO4.** Students will be trained in separation techniques used in molecular Biology which will be supportive in their future research (K1,K3,K4 & K6) **CO5.** Industrial visits will provide the students with an opportunity to learn practically through interaction, working methods and employment practices. Students will have an exposure to Industrial standard and current work practices (K1,K2,K3,K4 & K6)
Units	

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

	Pearson Education Inc 6. Practical Enzymology, Second Revised Edtion: Hans Bisswanger, Wiley – Blackwell; 2 edition (2011)

Method of Evaluation:

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

Methods of assessment:

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

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

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

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

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

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

Mapping with Programme Outcomes:

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

S-Strong M-Medium L-Low

Semester	23PBIOE24-1 : ELECTIVE PAPER–III (Discipline centric) CLINICAL BIOCHEMISTRY	H/W	C
II		4	3

Pre-requisites, if any:	The student should have a basic knowledge of body fluids and their composition and metabolism; anatomy and physiology of vital organs.
Course Objectives	1. To understand the need and methods of various biological sample collection. 2. To explicitly understand the etiopathogenesis, symptoms and complications of metabolic and hormonal disorders and the relevant diagnostic markers 3. To emphasize the diagnostic significance of serum enzymes in different pathologies and other Laboratory investigations of diagnostic importance so as to differentiate normal from disease 4. To conceive the role of inherited genes in inborn errors of metabolism and methodologies pertaining to *in utero* diagnosis and post-natal screening. 5. To get updated about electrolyte and hormonal imbalances and the biochemical tests to diagnose them.
Course Outcomes	**CO1.** To appreciate the biological significance of sample collection and awareness of the diagnostic/screening tests to detect common non-communicable diseases so as to understand role of laboratory investigations for biochemical parameters and understand the disorders associated with blood cells **CO2.** To understand the etiology of metabolic diseases like diabetes and atherosclerosis and avoid such lifestyle disorders by healthy eating and correlate the symptoms with underlying pathology based on diagnostic and prognostic markers. **CO3.** To understand the diagnostic application of serum/plasma enzymes to correlate their levels with the organ pathologies associated with specific diseases.

	CO4. To appreciate the role of pre and post-natal diagnosis leading to healthy progeny. **CO5.** To link the serum hormone levels and clinical symptoms with underlying hormonal disturbances. To review the onward transmission of signal via downstream signaling molecules from cell surface to the nucleus by different pathways by comparing and contrasting them and critically evaluate the network between them resulting in the biological outcome.
Units	
I	**Biochemical investigations in diagnosis, prognosis, monitoring, screening:** Specimen collection – blood, (primary /Secondary specimen)., urine and CSF. Preservation of biological specimens -blood, urine, CSF and amniotic fluid. ; . Biological reference ranges; **Disorders of blood cells**: Hemolytic, iron deficiency and aplasticanemia and diagnosis, sickle cell anaemia, thalassemia HBA1C variants. Porphyrias, Thrombocytopenia, Causes of leucopenia, leukemia and leucocytosis. Disorders of blood clotting mechanism - Von willebrand's disease, Hemophilia A, B and C, diagnostic test for clotting disorders, D-dimer and its clinical significance
II	**Diabetes mellitus: pathology and complications:** Acute changes; Chronic complications: Diabetic nephropathy, neuropathy, retinopathy and Diabetic foot ulcers, Random/Fasting/PP glucose testing, Impaired glucose tolerance (IGT), Impaired fasting glucose (IFT), Diagnosis-by GTT, Pre-diabetes, Gestational DM ,Glycosylated Haemoglobin (HBA1c) ; Glycated albumin., Hypoglycaemia and critical alert value for glucose. Markers of complications of Diabetes mellitus: Metabolic syndrome, Lipid profile &lipoproteinemia, Atherosclerosis, Diabetic nephropathy, Micralbuminuira, eGFR. Point of care testing for glucose (Glucometers) and continuous glucose monitoring (CGM) : principle and its use. Major groups of anti-diabetic drugs. Diet and life style modifications
III	**Diagnostic Enzymology:** Clinically Important Enzymes and Isoezyme as diagnostic markers: Clinical significance of AST, ALT, ALP, ACP, CK, γ-GT, amylase, pseudocholinesterase and their pattern in .Myocardial infarction; Liver disease, Bone disease, Muscle disease, Cancer (tumor markers), GI tract pancreatitis); Enzymes as therapeutic agents. **Pre- and post-natal testing:** Amniocentesis, prenatal detection of inborn errors of metabolism in developing fetus- Autosomal recessive mode of inheritance-cystic fibrosis, X linked recessive inheritance-Duchenne muscular dystrophy. New born screening (NBS) for In born errors of metabolism, Tandem mass spectrometry application in NBS

IV	**Liver function tests:** Liver function test panel, Fatty liver . Plasma protein changes in liver diseases. Hepatitis A ,B and C. Cirrhosis and fibrosis. Portal hypertension and hepatic coma.Acute phase proteins -CRP, Haptoglobins, α-fetoprotein, ferritin and transferrin and their clinical significance, Interpreting serum protein electrophoresis. Inflammatory markers (cytokines such as TNF-alpha IL6 and others)
V	**Renal function tests** - tests for glomerular and tubular function-Acute and chronic renal failure-Glomerulonephritis, Nephrotic syndrome, uraemia-urinary calculi-Nephrocalcinosis and Nephrolithiasis-causes, pathology and symptoms. Chronic kidney disease. Dialysis-Hemodialysis and peritoneal dialysis. **Electrolyte disorder :** calcium: hypercalcemia and hypocalcemia; Calcium homoestasis in Blood; phosphate: hyperphosphatemia or hypophosphatemia; Clinical significance: Potassium: hyperkalaemia and hypokalaemia, Sodium: hypernatremia and hyponatremia; Chloride: hyperchloremia, hyporchloremia **Hormonal disorders and diagnostics:** T3, T4 and TSH in the diagnosis of thyroid disorders; Diagnostic methods for disorders associated with adrenal, pituitary and sex hormones - Addison's disease, Cushing's syndrome, pituitary tumour, Hypopituitarism, Hypogonadism
Self-Study	**1. Potential sources of variability in the estimation of the analytes:** Pre-analytical phase: acceptance rejection criteria in terms of haemolysis/icteric/lipemia (HIL) interferences Analytical phase: Linearity, detection limits precision, accuracy, specificity, sensitivity; Total Allowable Error. (Definitions and examples). Post-analytical phase **:** Units of reporting of clinical chemistry parameters- **2. Interpretation of results in clinical chemistry based on laboratory investigations and quality control:** • critical / alert values • American Diabetes Association (ADA) Standards of Medical Care in Diabetes (yearly update); HBA1C testing :NGSP • Case studies to review • Quality control for clinical chemistry in laboratory
Recommended Texts	1. ThomasM.Devlin (2014) Textbook of Biochemistry with Clinical Correlations (7th ed). John Wiley & Sons 2. Montgomery R, Conway TW, Spector AA (1996),Biochemistry: A Case-Oriented Approach (6th ed), Mosby Publishers, USA. 3. Tietz Fundamentals of Clinical Chemistry and Molecular Diagnostics (2018) (8th ed),Saunders 4. Dinesh Puri, (2020) Text book of Biochemistry: A clinically oriented approach – 4th Edition, Elsevier. 5. 5. M.N.Chatterjee and Rana Shinde (2012).Textbook of Medical Biochemistry (8th ed), Jaypee Brothers Medical Publishers. 6. Clinical Case Discussion In Biochemistry A Book On Early Clinical Exposure (ECE), Poonam Agrawal , 2021, CBS Publishers & distributors pvt. Ltd

Method of Evaluation:

Test I	Test II	Assignment	End Semester	Total

			Examination	
10	10	5	75	100

Methods of assessment:

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

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

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

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

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

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

Mapping with Programme Outcomes:

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

S-Strong M-Medium L-Low

Semester	23PBIOE24-2 : ELECTIVE PAPER–III (Discipline centric)	H/W	C
II	RESEARCH METHODOLOGY	4	3

Pre-requisites, if any:	The student should have a basic knowledge of research and statistics.
Course Objectives	1. To impart knowledge on research problem and finding scientific articles with Internet. 2. To provide knowledge on collection and analysis of data using statistical tools. 3. To create awareness on sampling and test of goodness of fit 4. To impart basic knowledge on animal experimentation and intellectual property rights. 5. To develop sound knowledge on preparation of research reports.
Course Outcomes	CO1 Familiar with search engines and identify a research problem by searching relevant literature. CO2 Well versed with data collection and analysis of data using statistical tools. CO3 Able to do the procedures of sampling and test of significance \ CO4 Familiar with ethics in animal experimentation and well versed with CPCSEA guidelines. CO5 Gain knowledge to write an effective research articles and research proposal
Unit	
I	Identifying a research problem and searching relevant literature. Boolean Searching. Use of Search Engines. Finding Scientific Articles – Google, PubMed, DELNET, INFLIBNET. Statistical survey – Organizing, planning and executing the survey. Source of data - Primary and secondary data, collection, observation, interview, enquiry forms, questionnaire schedule and check list. Classification and tabulation of data. Diagrammatic and graphic presentation of data.
II	Measures of central tendency - arithmetic mean, median, mode, quartiles, deciles and percentiles. Measures of variation - range, quartile deviation, mean deviation, standard deviation, Coefficient of variation. Correlation analysis - Scatter diagram, Karl's Pearson's coefficient of correlation and Spearman's rank method. Regression analysis.

III	Sampling distribution and test of significance – Concepts of sampling, Testing of hypothesis, errors in hypothesis testing, standard error and sampling distribution, sampling of variables (large samples and small samples.). Student's "t" distribution and its applications. Chi-square test and goodness of fit. Analysis of variance - one way and two way classification.
IV	Ethics in animal experimentation. CPCSEA guidelines - Animal care and technical personnel environment, animal husbandry, feed, bedding, water, sanitation and cleanliness, waste disposal, anesthesia and euthanasia. Composition of (Human) institutional Ethical Committee (IEC) - General ethical issues. Patenting - definition of patent. Product and process patents. Patenting multi cellular organisms. Patenting and fundamental research
V	Components of a research report - Title, Authors, Abstract, Synopsis, Keywords, Introduction, Materials and Methods, Results, Discussion, Acknowledgement, Summary or Conclusions, References. Plagiarism. Significance of Impact Factor. Preparation of a research proposal for funding. Indian funding agencies for research-student research proposal submission to TNSCST and TANSCHE. Literature Citation: Name-Year System (Harvard System), Citation-Sequence System, Alphabet Number System; Journal Abbreviations. Format and use of Tables and figures in a research reports
Reading List (Print and Online)	www.research.org www.pubmed
Self-Study	Statistical survey – Organizing, planning and executing the survey.
Recommended Texts	1. Gurumani, N. Research Methodology for Biological Sciences. MJP Publishers, Chennai 2006. 2. CPCSEA Guidelines for Laboratory Animal Facility, CPCSEA, 2003. 3. Day, R.A, Gastel B. How to Write and publish a Scientific Paper. Cambridge University Press, 8th Edition. 2017. 4. Gupta, S.P. Statistical Methods. Sultan.Chand & Sons, 2011. 5. Kothari. C.R, Research Methodology, methods and techniques, new age International (P) limited, publishers, 2004

Method of Evaluation:

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

Methods of assessment:

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

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

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

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

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

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

Mapping with Programme Outcomes:

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

S-Strong M-Medium L-Low

Semester	23PBIOE25-1 : ELECTIVE PAPER–IV (Generic centric)	H/W	C
II	ENERGY AND DRUG METABOLISM	4	3

Pre-requisites	Basic knowledge on biochemical reactions such as addition, deletion, rearrangement, transfer and breaking of bonds
Course Objectives	1. Familiarize on concepts of enthalpy, entropy, free energy, redox system, biological oxidation and high energy compounds 2. Provide an insight into the relationship between electron flow and phosphorylation 3. Inculcate knowledge on processes involved in converting light energy to chemical energy and associated food production by autotrophs 4. Provide a platform to understand the versatile role of Krebs cycle, transport of NADH across mitochondrial membrane and energetics 5. Educate on the various phases xenobiotic metabolism
Course Outcomes	**On successful completion of this course, students should be able to:** After completion of the course, the students should be able to: **CO1.** Appreciate the relationship between free energy and redox potential and will be able to justify the role of biological oxidation and energy rich compounds in maintaining the energy level of the system (**K1,K2,K3,K4**) **CO2.** Gain knowledge on role of mitochondria in the production of energy currency of the cell **(K1, K2, K5, K6)** **CO3.** Acquaint with the process of photosynthesis **(K1,K2,K5)** **CO4.** Comprehend on the diverse role of TCA cycle and the energy obtained on complete oxidation of glucose and fatty acid **(K1,K2,K4,K5)** **CO5.** Correlate the avenues available to metabolize the xenobiotics **(K1, K2,K4,K5)**
Units	
I	Thermodynamic- principles in biology- Concept of entropy, enthalpy and free energy change. Redox systems. Redox potential and calculation of free energy. Biological oxidation – Oxidases, dehydrogenases, hydroperoxidases, oxygenases. Energy rich compounds – phosphorylated and non-phosphorylated. High energy linkages.
II	Electron transport chain-various complexes of ETC, Q-cycle. Inhibitors of ETC. Oxidative phosphorylation-P/O ratio, chemiosmotic theory. Mechanism of ATP synthesis - role of F0-F1 ATPase, ATP-ADP cycle. Inhibitors of oxidative phosphorylation ionophores, protonophores .Regulation of oxidative phosphorylation
III	Light reaction-Hills reaction, absorption of light, photochemical event. Photo ETC-cyclic and non-cyclic electron flow. Photophosphorylation-role of CF0-CF1 ATPase. Dark reaction- Calvin cycle, control of C3 pathway, and Hatch-Slack pathway (C4 pathway), Photorespiration. Synthesis and degradation of

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

Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade

10	10	5	75	100	

Methods of assessment:

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

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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	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

Semester	23PBIOE25-2 : ELECTIVE PAPER–IV (Generic centric) BIOINFORMATICS	H/W	C
II		4	3

Pre-requisites	Basic knowledge on Computer operation, Strong knowledge about Molecular biology and Biostatistics
Course Objectives	1. Understand the basics concepts of Bioinformatics and its significance in Biological data analysis. 2. Able to understand the different biological databases. 3. Overview about the biological macromolecular structures. 4. Become familiar with a variety of currently available genomic and proteomic databases 5. Learn how to compare and analyze biological sequences
Course Outcomes	**On successful completion of this course, students should be able to:** After completion of the course, the students should be able to: **CO1** Explain the concepts of biology in Computer science and scope of bioinformatics. **CO2** Illustrate the types of biological data bases. **CO3** Appraise the features of DNA sequence analysis. **CO4** Understand the concepts of FASTA & BLAST. **CO5** Explain the applications of bioinformatics.
Units	
I	History of Bioinformatics Objectives and scope of Bioinformatics Fields related to Objectives, scope, genome mapping as a source of Bioinformatics , Search Engines.
II	DNA, RNA and Proteins. Online resources for Bioinformatics – Biological Databases – NCBI, Genbank, EMBL, Swissprot, PDB. Executing search and retrieval of data. Sequence alignment – Multiple sequence alignment – Pairwise alignment.
III	Gene sequencing tools traditional methods – Maxam and Gilbert's method, Sanger's sequencing – structure prediction tools – Nucleic acid and protein structure prediction – Gene and protein expression analysis – similarity search databases – FASTA, BLAST. Analysis of Phylogeny - Phylogenetic tree construction
IV	Structure based drug discovery – Molecular docking of novel compounds – SAR and QSAR, Introduction to Simulation softwares in biology – Autodock, ADMET.

V	Visualization tools and Applications of Bioinformatics 12 Hours Protein structure visualization tools – RasMol, HEX, Argus Lab Swiss PDB Viewer - Structure Classification, alignment and analysis – SCOP, CATH, FSSP, UNIX. Medicine, Agriculture, Environmental monitoring - Emerging areas in bioinformatics.
Reading List (Print and Online)	www.pubmed www.ncbi.nlm.org www.fasta www.blast
	Search engines, retrieving data
Recommended Texts	• Manoj Kumar, (2020) Introduction to Bioinformatics Notion press. • Shoba Ranganathan, Kenta Nakai, Christian Schonbach (2018) Encyclopedia of Bioinformatics and Computational Biology: ABC of Bioinformatics Elsevier • Hamid R Arabnia, Quoc Nam Tran Emerging (2015) Trends in Computational Biology, Bioinformatics, and Systems Biology: Algorithms and Software Tools (Emerging Trends in Computer Science and Applied Computing) Morgan Kaufmann; 1st Edition • Asheesh Shanker , (2018) Bioinformatics: Sequences, Structures, Phylogeny Springer • Paola Lecca, (2011)Systemic Approaches in Bioinformatics and Computational Systems Biology: Recent Advances Business Science Reference • Arthur Lesk (2019) Introduction to Bioinformatics Oxford University Press • Jamil Momand, Alison McCurdy, Silvia Heubach (2016) Concepts in Bioinformatics and Genomics ,Oxford University Press

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

Semester	23PBIOS26 : Skill Enhancement Course (Sec-I)	H/W	C
II	ORGANIC FARMING	4	2

Pre-requisites	Basic knowledge about forming and cultivation process
	1. Students will learn about the cultivation process of organic farming .2. Able to differentiate between chemical and organic pesticides
Course Outcomes	**On successful completion of this course, students should be able to:** **CO1:** Able to differentiate between normal and organic farming(K1) **CO2:** Understand the organic farming practices(K4 & K5) **CO3:** Know the health benefits of organic farming **CO4**: Aquire knowledge about the hazardous effects of Chemical fertilizers **CO5:** Know about the entrepreneurship opportunities in organic farming

Units	
I	**Concept of organic farming** Introduction:Farming, organic farming, concept and development of organic farming. Principles and Types of organic farming Benefits of organic farming.
II	**Organic plant nutrient management** Organic farming systems- Soiltillage- Land preparation and mulching Water management
III	**Organic plant protection** Plant protection-cultural-mechanical- -biopesticide-biocontrol agents-organic vermicompost .
IV	**Organic crop production practices** Organic crop production methods-rice-vegetables- amaranthus-medicinal and aromatics plants , Income generation activities: Apiculture, Mushroom production, Terrace farming .Quality of Organic Food,-natural source for antioxidants for health defence-antioxidant capacity of fruits and vegetables

V	**Entrepreneurship Development** Organic food and human health -organic certification process -marketing of organic product to increase Entrepreneurship -Dates Processing & Packaging -production of Fruit Juices, Making of Organic Jams, Production of Organic Honey
Reading List (Print and Online)	E-References: www.irri.org www.crri. nic.in www.drrindia.org
Self-Study	Organic farming practices
Recommended Texts	1 Ahlawat, I.P.S., Om Prakash and G.S.Saini. 1998. Scientific Crop Production in India. Rama Publishing House, 2. Meerut.Chidda Singh.1997. Modern techniques of raising field crops. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi. • ICAR 2006. 3. Hand book of Agriculture. Indian Council of Agricuture, New Delhi. • Crop Production Guide. 2005. Directorate of Agriculture, Chennai and Tamil Nadu Agricultural University, Coimbatore. 4.Rajendra Prasad. 2004. Text Book on Field Crop Production, Indian Council of Agrl. Research, New Delhi. 5. K Annadurai and B Chandrasekaran. 2009. A Text Book Of Rice Science. Scientific Publisher

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

SECOND YEAR: SEMESTER – III

Core-VII	23PBIOC31: Industrial Microbiology	Credit	5
II Year		Hours/ Week	6
III Semester			

Pre-requisites, if any:	Basic Knowledge of Microbiology and microbial techniques
Course Objectives	1. To gain knowledge of the structure, classification and use of microorganisms in various industries. 2. To know various fermenter designs, culture systems and the application of fermentation process in industry. 3. To understand the production and purification of fermented products and their industrial applications. 4. Understand the basic concepts of food and agricultural microbiology.
Course Outcomes	**CO1**.Students will be able to understand the structure and classification of microorganisms (K2 , K4) **CO2**.Gain knowledge of the uses of microorganisms in various industrial applications (K3 , K4) **CO3**.Understand the concepts of fermentation process, harvest and recovery. (K1 , K5) **CO4**.Students will know the types of microbial fermentation processes and their applications in pharmaceutical industry. (K2 , K3) **CO5**.Students will learn about the use of microorganisms in beverages, diary and food industries. (K3 , K6)
Units	
I	Structure of bacteria, fungi and viruses and their classification. Types and characteristics of microorganisms used in Industry (a) Food Industry (b) Chemical Industry (c) Pharmaceutical Industry
II	Fundamentals and principles of microbial fermentation techniques – application in industry and pharmaceutical Biochemistry. Fermentation – types, techniques, design and operation of fermenters including addition of medium. Types and characteristics of microorganisms, environmental conditions required for the growth and metabolism of industrially and pharmaceutically important microbes. Sterilization methods in fermentation techniques, air, gas, culture medium sterilization. Steam-filtration and chemicals. Types and constituents of fermentative culture medium and conditions of fermentations, Antifoaming devices.
III	Recovery and estimation of products of fermentation- Production of ethanol, acetic acid, glycerol, acetone, butanol and citric acid by fermentation. Production of Enzymes- amylase, protease, lipase,Production of pharmaceuticals by fermentation– penicillin, streptomycin, tetracycline, riboflavin, vitamin B12.Beverages-wine, beer and malt beverages.

IV	Food Microbiology: Production of dairy products-bread, cheese and yoghurt (preparation and their types). Food borne diseases- Bacterial and Non-Bacterial. Food preservation - Principles–Physical methods: temperature (low, high, canning, drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging, Chemical methods - salt, sugar, organic acids, SO_2, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins.
V	Agricultural Microbiology: General Properties of soil, microorganisms in soil – decomposition of organic matter in soil. Biogeochemical cycles, nitrogen fixation, Production of bio fertilizers and its field applications – Rhizobium, azotobacter, blue green algae, mycorrhizae, azospirilium, Production of biofuels (biogas- methane), soil inoculants.
Self-Study	• Micro-organisms in food processing and pharma industries • Upstream and Downstream processes in Biopharma
Reading List (Print and Online)	Industrial biotechnology: https://nptel.ac.in/courses/102/105/102105058/ Bioreactors: https://nptel.ac.in/courses/102/106/102106053/ Food Microbiology: https://nptel.ac.in/courses/126/103/126103017/ Agriculture Microbiology: https://www.youtube.com/watch?v=f7UXyVImZ_c
Recommended Texts	1. Food Microbiology: An Introduction: 4th edition,**Matthews KR, Kniel KE, Montville TJ;** American Society for Microbiology 2. Food, Fermentation and Micro-Organisms,2nd edition, **Charles, BW;** Blackwell Science Ltd 3. Microbiology. 5th edition , **Pelczar MJ, Chan ECS and Krieg NR**; McGraw Hill Book Company. 4. Text book of Microbiology:11th edition, **Ananthanarayanan R and Paniker CKJ;** Universities Press (India) Pvt. Ltd. 5. Food Microbiology, 3rd edition, **Frazier WC and Westhoff DC;**Tata McGrawHill Publishing Company Ltd, New Delhi 6. New Methods of Food Preservation:1st edition, **Gould GW**; Springer Manual of Industrial Microbiology and Biotechnology**:** 3rd edition, **Baltz**

Method of Evaluation:

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

Methods of assessment:

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

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

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

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

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

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

Mapping with Programme Outcomes:

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

S-Strong M-Medium L-Low

Core-VIII	23PBIOC32: Molecular Biology	Credit	5
II Year		Hours/ Week	6
III Semester			

Pre-requisites, if any:	Knowledge of the basics of genetics, cell biology and molecular biology.
Course Objectives	1. To introduce the students to the process of inheritance, concepts of genes, genome, chromatin and chromosomes. 2. To impart a thorough understanding of the key events of molecular biology, including the mechanisms of DNA replication, transcription and translation along with DNA repair mechanisms. 3. To provide a detailed understanding of post transcriptional and posttranslational modifications and processing of eukaryotic RNA and proteins 4. To give a detailed explanation of transcriptional regulation with lac operon and tryptophan operon as examples 5. To impart adequate information of the types of regulatory RNAs along with key concepts of gene silencing
Course Outcomes	After completion of the course, the students should be able to: **CO1:** Comprehend the organization of genomes, the molecular basis of DNA replication, recombination and transposition, the significance of these processes, the various ways in which the DNA can be damaged leading to mutations and lesions and the different ways in which they are repaired.(K1,K2,K3,K5) **CO2:** Gain knowledge about how genes are transcribed and translated in prokaryotes and eukaryotes and how these processes are regulated, recognize the nature of the genetic code and the various experimental approaches used to crack the code (K1,K2,K3,K4,K5) **CO3:** Acquire knowledge of the molecular basis of RNA processing and RNA splicing and the various human pathologies that can result from defects of RNA modification. (K1,K2,K4,K5) **CO4:** Comprehend the techniques of gene silencing and its applications.(K1,K2,K3,K4,K5,K6) **CO5:** Apply the knowledge they have gained in understanding the above vital life processes to enhancing their analytical and problem-solving skills and develop an interest to pursue high quality research. (K2,K3,K4,K5,K6)

Units	
I	Mendel's laws of inheritance-dominance-complete, incomplete and co-dominance, multiple alleles-gene mapping in haploids and diploids, recombination mapping- restriction mapping- modes of gene information transfer in bacterial- conjugation, transformation and transduction. The bacterial chromosome, the eukaryotic genome- chromosome structure – Histones, Nucleosome, chromatin- heterochromatin, euchromatin, chromatin remodeling, DNAase hypersensitive sites, genome organization – the C-value paradox, reassociation kinetics, repetitive sequences, gene amplification, telomeres, pseudogenes, split genes, organelle genomes – mitochondrial and chloroplast genome.
II	DNA replication and repair: Enzymes of replication, prokaryotic replication mechanisms, primosome & replisomes, eukaryotic DNA replication, the role of topoisomerases and telomerase, regulation of replication, difference between prokaryotic and eukaryotic replication. Mutations -Types of mutations, mechanisms of mutations, mutagenic agents. DNA repair mechanisms – Direct repair, excision repair, mismatch repair, recombination repair, SOS response, eukaryotic repair systems. Recombination and mobile genetic elements- the Holliday model, the general recombination in *E.coli*, site specific recombination, transposons and retroposons.
III	Transcription – Prokaryotic transcription-subunits of RNA polymerase, E. coli promoters, sigma factor and promoter recognition, alternative sigma factors, initiation, elongation, Rho-dependent and independent termination of transcription. Eukaryotic transcription- Initiation, promoter elements, RNA polymerases, transcription factors, regulatory sequences in eukaryotic protein – coding genes, CpG islands, enhancers. Translation – organization of the ribosome, the genetic code, evidence for a triplet code, deciphering the genetic code, wobble hypothesis, deviation in the genetic code, unusual codons. activation, initiation, elongation and termination of translation in E. coli. The role of tRNA and rRNA, suppressor tRNAs and inhibitors of protein synthesis., Comparison of prokaryotic translation with eukaryotic translation.
IV	Regulation of gene expression in prokaryotes-– Positive and negative control, the lac operon, identification of operator and regulator sequences by mutations, induction and repression, Foot-printing and gel-shift assays for identification of protein-DNA interactions. Catabolite repression. *Trp* operon – Attenuation, alternative secondary structures of *trp* mRNA. Regulation of gene expression in eukaryotes- Response elements, DNA-binding motifs, steroid receptors, association of methylation and histone acetylation with gene expression.
V	Post transcriptional modifications in eukaryotes- RNA processing- mRNA 5' capping and 3'poly-adenylation, introns and exons, RNA splicing,- spliceosome assembly, alternative splicing, processing of tRNA and rRNA, self-splicing, ribozymes, RNA editing- substitution and insertion/deletion editing, Genome editing-CRISPR- Cas technology Post translational modification of proteins- Proteolytic cleavage, covalent modifications, glycosylation of proteins, disulfide bond formation, Protein sorting – signal peptides, transport of secretory proteins, Golgi and post-golgi

	sorting, coated vesicles, targeting of mitochondrial, lysosomal and nuclear proteins, Protein degradation-Ubiquitination of proteins, Protein folding-chaperones
Reading List (Print and Online)	1. Molecular Biology Free Online Course by MIT Part 3: RNA Uploaded by edX 2. https://mooc.es/course/molecular-biology/ 3. https://onlinecourses.swayam2.ac.in/cec20_ma13/preview 4. https://learn.genetics.utah.edu/ 5. https://www.cellbio.com/education.html 6. https://lifescienceinteractive.com/category/molecular-biology/
Self-Study	1. Multiple roles of noncoding RNAs (long ncRNA ,siRNA, miRNA) in development and differentiation; implication of ncRNAs in pathologies. 2. mRNA degradation- nonsense-mediated decay.
Recommended Texts	1. Lewin's Genes XII : 12th edition, Krebs JE, Goldstein ES, Kilpatrick ST ;Prentice Hall, Delhi 2. Molecular Biology of the Gene : 6th edition, Watson JD , Baker TA, Bell S, Gann A, Levine M, Losick R; Cold Spring Harbor Laboratory Press, New York 3. Essential Cell Biology :3rd edition, Alberts B, Bray D, Hopkin K, Johnson A, Lewis J, Raff M, Roberts K, Walter P ; Garland Science, New York 4. Molecular Cell Biology : 8th edition , Lodish H, Arnold Berk; W.H.Freeman & Co, New York 5. Karp's Cell and Molecular Biology: Concepts and Experiments, 8th Edition; Wiley, India 6. An Introduction to Genetic Analysis 12th edition,, Griffith A. F, Doebley J, Peichel C, David A, Wassarman DA; Albion Press.W.H.Freeman & Co ,New York

Method of Evaluation:

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

Methods of assessment:

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

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

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

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

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

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

Mapping with Programme Outcomes:

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

S-Strong M-Medium L-Low

Core-IX	23PBIOC33: Gene Editing, Cell and Gene therapy	Credit	5
II Year		Hours/ Week	6
III Semester			

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

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

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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, Observe, Explain.

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

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

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

Mapping with Programme Outcomes:

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

S-Strong M-Medium L-Low

Core-X	23PBIOC34: Biostatistics and Data Science	Credit	4
II Year		Hours/ Week	6
III Semester			

Pre-requisites, if any:	Basic knowledge of Statistics and Computer Applications
Course Objectives	1. To summarize the data and to obtain its salient features from the vast mass of original data. 2. To understand the concept of various measures of dispersion. 3. To understand the concepts of sampling and learning test of significance. 4. To understand the concept of various attributes and relate to biological studies. 5. To gain knowledge in SPSS, a software package which gives a perfect graphical representation and appropriate result for the data that has been entered
Course Outcomes	After completion of the course, the students should be able to: **CO1:** Concepts of statistical population and sample, variables and attributes. Tabular and graphical representation of data based on variables.(K1,K2,K3) **CO2:**Conditions for the consistency' and criteria for the independence of data based on attributes. Measures of central tendency, Dispersion, Skewness and Kurtosis.(K1,K2,K3) **CO3**:Learning different sampling methods and analysing statistical significance.(K1,K2,K3,K4) **CO4:** Understanding students t test , ANOVA , Chi square test to analyse the significance of various research. (K1,K2,K3,K4) **CO5:** Learning on data science, algorithm for machine learning, artificial intelligence and big data, their applications in clinical and pharma domain . (K1,K2,K3,K4.K6)
Units	
I	Nature of biological and clinical experiments – Collection of data in experiment- Primary and secondary data. Methods of data collection. Classification and tabulation. Different forms of diagrams and graphs related to biological studies. Measures of Averages- Mean, Median, and mode. Use of these measures in biological studies.

II	Measures of Dispersion for biological characters – Quartile deviation, Mean deviation, Standard deviation and coefficient of variation. Measures of skewness and kurtosis. Correlation and regression – Rank correlation – Regression equation. Simple problems based on biochemical data.
III	Basic concepts of sampling- Simple random sample stratified sample and systemic sampling. Sampling distribution and standard error. Test of significance based on large samples. Test for mean, difference of means, proportions and equality of proportions.
IV	Small sample tests – Students't' test for mean, difference of two way means, tests for correlation and regression coefficients. Chi-square test for goodness of a non independence of attributes. F test for equality of variances. ANOVA- one way and two way. Basic concept related to biological studies
V	Introduction to Data Science, Definition of data science, importance, and basic applications, Machine Learning Algorithms, Deep Learning, Artificial Neural Networks and their Application, Reinforcement Learning, Natural Language Processing Artificial Intelligence (AI), Data Visualization, Data Analysis, Optimization Techniques, Big Data, Predictive Analysis. Application of AI in medical, health and pharma industries.
Reading List (Print and Online)	1. https://www.ibm.com/docs/en/SSLVMB_28.0.0/pdf/Accessibility.pdf 2. https://pure.tue.nl/ws/portalfiles/portal/19478370/20160419_CO_Mzolo.pdf 3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5453888/ 4. https://home.ubalt.edu/ntsbarsh/excel/excel.htm 5. https://students.shu.ac.uk/lits/it/documents/pdf/analysing_data_using_spss.pdf 6. https://www.ibm.com/support/pages/ibm-spss-statistics-28-documentation
Self-Study	1. Simple problems on probability, theoretical distributions, hypothesis testing 2. Relationship between mean, median and mode pros and cons of the measures of central tendency and deviation
Recommended Texts	1. Zar, J.H. (1984) "Bio Statistical Methods", Prentice Hall, International Edition 2. Sundar Rao P. S.S., Jesudian G. & Richard J. (1987), "An Introduction to Biostatistics", 2nd edition,. Prestographik, Vellore, India,. 3. Warren,J; Gregory,E; Grant,R (2004), "Statistical Methods in Bioinformatics",1st edition,Springer 4. Milton,J.S.(1992),. "Statistical methods in the Biological and Health Sciences", 2nd edition ,Mc Graw Hill, 5. Rosner,B (2005), "Fundamentals of Biostatistics", Duxbury Press 6. Introducing Data Science, Davy Cielen, Anro DB Meysman, Mohamed Ali.

Method of Evaluation:

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

Methods of assessment:

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

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

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

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

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

Create (K6) - Check knowledge in specific or off beat situations, Discussion, Presentations

Mapping with Programme Outcomes:

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

S-Strong M-Medium L-Low

Elective-V	**23PBIOE35: Molecular basis of disease and therapeutic strategies**	**Credit**	**3**
II Year		**Hours/ Week**	**3**
III Semester			

Pre-requisites, if any:	Knowledge of Human Physiology, Metabolism and Clinical Biochemistry
Course Objectives	1.To understand the concepts of the mechanisms involved in regulation of blood sugar and management of diabetes mellitus 2.To gain in-depth knowledge of the mechanisms of cancer and of tumor metastasis 3.The student will review the basic organization of the central and peripheral nervous system that coordinate the sensory and motor functions of the body. In addition, the student will explore impaired features underlying the major neuropathological complications. 4.To gain knowledge in renal diseases 5.To understand the mechanisms involved in cardiac disorders
Course Outcomes	**On completion of this course the student will be able to understand** **CO1.**Overall view about the complications of diabetes mellitus and its management. **CO2.**Comprehensive understanding of the concepts of cancer biology and implicating the theoretical concepts for further research **CO3**.Understand and appreciate the pathophysiology of conditions affecting the nervous system. **CO4**.A thorough knowledge of renal and cardiac diseases with emphasis related to mechanistic aspects and therapeutic interventions. **CO5.** A thorough knowledge on the experimental models of non-communicable diseases that will be applied for future research or project dissertation. An in-depth knowledge on development of drugs against non-communicable diseases.
Units	
I	Mechanism of blood sugar regulation in human body. Pathophysiology of Type I and II diabetes, Diabetes – investigation methods for the diagnosis of diabetes. Nutritional care. Complications related to diabetes – Diabetic cardiovascular disease, retinopathy, neuropathy and nephropathy. Cellular and molecular mechanism of development of diabetes- Management of Type I and Type II diabetes, drugs for the treatment of diabetes.

II	Biology of cancer: Overview of hallmarks of cancer. Tumorigenesis, Tumor progression and mechanism of Metastasis. Proto-oncogene to oncogene. Oncogene- myc and src family. Tumor suppressor gene-Rb and p53 pathway in cancer. Diagnosis- Non-invasive imaging techniques, Tumor diagnosis, Interventional radiology, New imaging technique, Molecular techniques in cancer diagnosis.- treatment of cancer- surgery, radiotherapy, chemotherapy, hormonal treatment, and biological therapy. Introduction to personalized medicine.
III	Brain- neuronal network- memory- Neurogenerative diseases- Parkinson and Alzheimer Disease- molecular understanding of the neurodegenerative diseases- treatment modalities.
IV	Acute and chronic renal failure, glomerular diseases–glomerulonephritis, nephritic syndrome, diabetes insipidus, diagnosis of kidney disease.
V	Introduction to cardiovascular diseases, Lipids and lipoproteins in coronary heart disease-cardiac enzymes, Molecular changes during cardiac remodeling – hypertrophy of hearts – heart failure- treatment modalities.
Reading List (Print and Online)	1. The Biochemical basis of disease:2018, **Barr AJ;** Portland Press 2. Biochemical Basis of Diseases 3. https://www.biologydiscussion.com/diseases-2/biochemical-basis-of-diseases/44276
Recommended Texts	1. Wills' Biochemical Basis of Medicine: 2nd edition, Thomas H, Gillham B;Elsevier 2. Molecular Biochemistry of Human Diseases,2021, Feuer G ,de la Iglesia F; CRC Press

Method of Evaluation:

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

Methods of assessment:
Recall (K1) - Simple definitions, MCQ, Recall steps, Concept definitions

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

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

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

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

Mapping with Programme Outcomes:

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

S-Strong M-Medium L-Low

Skill Enhancement Course (SEC)-II	**23PBIOS36: Laboratory Course on Clinical Biochemistry (Practical)**	**Credit**	**2**
II Year		**Hours/ Week**	**3**
III Semester			

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

I	Haematology: RBC count, WBC count – total and differential count, ESR, PCV, MCV. Bleeding Time, Clotting Time and Estimation of hemoglobin. Determination of Electrolytes :Sodium, Potasium and Calcium
II	Liver function test: Estimation of bilirubin – direct and indirect. Estimation of plasma protein, A/G ratio, Thymol turbidity test, Prothrombin Time (PT),Assay of serum glutamate oxaloacetate transaminase, alkaline phosphatase, Gamma-glutamyltransferase (GGT), isoenzyme separation of LDH by electrophoresis.
III	Renal function test: Collection and Preservation of Urine sample Qualitative tests for normal and pathological components of urine. BUN: Estimation of blood Urea, creatinine, and uric acid. Urea Clearance test
IV	Estimation of blood glucose by orthotoluidine and glucose oxidase method. Determination of glycosylated Hb. Glucose tolerance test. Kit method Lipid profile: Estimation of cholesterol by Zak's method, lipoprotein profile, estimation of ketone bodies, estimation of triglycerides, free fatty acids and phospholipids.
V	Group Experiments a. Antigen – Antibody Reaction - HCG kit method , RA kit method b. Phlebotomy –Venipuncture , Different techniques of venipuncture c. Collection of blood ,Serum or Plasma separation and Storage d. Automation in Clinical Biochemistry -Autoanalyser ,Semiautoanalyser
Reading List (Print and Online)	1. https://www.researchgate.net/publication/260182512_ Practical_Manual_in_Biochemistry_and_Clinical_Biochemistry 2. https://main.icmr.nic.in/sites/default/files/upload_documents/ GCLP_Guidelines_2020_Final.pdfhttps://www.westgard.com/clia.html 3. https://www.researchgate.net/publication/263929434_Biochemistry 4. https://ucms.ac.in/Lectures-C-2020/Renal%20function%20Tests%20-%20PPT.pdf 5. https://youtu.be/i2PfjEks4GQ 6. https://www.euro.who.int/__data/assets/pdf_file/0005/268790/WHO-guidelines-on-drawing-blood-best-practices-in-phlebotomy-Eng.pdf
Self-Study	1. Laboratory handling of human biological specimen 2. Automation in Clinical Biochemistry
Recommended Texts	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.

	23PBIOI37: SUMMER INTERNSHIP	**Credit**	**2**
II Year		**Hours/ Week**	**-**
III Semester			

(Refer to the Regulations)

Semester-IV

Core-XI	**23PBIOC41:Pharmaceutical Biochemistry**	**Credit**	**5**
II Year		**Hours/ Week**	**6**
IV Semester			

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

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

Method of Evaluation:

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

Methods of assessment:

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

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

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

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

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

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

Mapping with Programme Outcomes:

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

Core-XII	**23PBIOC42:Biochemical Toxicology**	**Credit**	**5**
II Year		**Hours/ Week**	**6**
IV Semester			

Pre-requisites, if any:	The student should have a basic knowledge of pharmacology of drug action and understanding on their biochemical pathways.
Course Objectives	1. To understand the detailed study of biochemical basis of drugs and its toxicity, particularly their actions on living systems. 2. To understand the relevance and methods to identify the chemotherapeutic value of drug. 3. To understand the fundamentals of toxicology and dose- response relationships. 4. To understand the toxicological drug testing procedures based on in vitro and animal studies 5. To understand biochemical pathways of drug toxicity and its manifestation on vital organs.
Course Outcomes	On completion of this course, the student will be able **CO1:** To appreciate and understand the role of toxicological biomarkers to assess drug toxicities. **CO2:** To conceive the role of disposition of drug in human system and their metabolism and methodologies pertaining to toxicological studies. **CO3:** To understand and evaluate the functions of different organs on drug disposition and associated drug toxicities. **CO4 :** To understand the toxicological response to foreign compounds and their pharmacological, physiological and biochemical effects. **CO5:** To link the mechanism of toxicity and clinical symptoms with underlying physiological disturbances.
Units	
I	Fundamentals of Toxicology and dose-Response Relationships: Introduction Biomarkers Criteria of Toxicity New Technologies Evaluation of Toxicity Interactions; Dose Response; Measurement of Dose-Response; Relationships Linear Dose Response Hormesis; Hazard and Risk Assessment Duration and Frequency of Exposure and Effect
II	Factors Affecting Toxic Responses: Disposition: Absorption ,Sites of absorption, distribution, Excretion; Metabolism: types of Metabolic change phase I reactions; Phase 2 reactions; control of Metabolism, Toxication vs. Detoxication

III	Toxicity testing; Test protocol, Genetic toxicity testing & Mutagenesis assay: In vitro test systems: bacterial mutation tests-Reversion test,Ames test, Fluctuation test, and Eukaryotic mutation test. In vivo test system Mammalian mutation test-Host mediated assay and Dominant Lethal test. Biochemical basis of toxicity: Mechanism of toxicity: Disturbance of excitable membrane function, Altered Calcium homeostasis, Covalent binding to cellular macromolecules & genotoxicity, Tissue specific toxicity
IV	Toxic Responses to Foreign Compounds: Direct Toxic Action: Tissue Lesions; Mechanism and response in cellular toxicity, pharmacological, physiological and Biochemical effects; Developmental Toxicology- Teratogenesis; Immunotoxicity Genetic Toxicity; Chemical Carcinogenesis
V	Biochemical Mechanisms of Toxicity: Tissue Lesions: Liver Necrosis; kidney Damage; Lung Damage, Liver damage, Cardiac damage; Neurotoxicity; Exaggerated and Unwanted pharmacological effects; Physiological effects; Biochemical Effects: Lethal Synthesis and Incorporation, Interaction with specific Protein Receptors; Teratogenesis; Immunotoxicity; multi-Organ Toxicity
Self-Study	• Case studies to review
Reading List (Print and Online)	1. Preclinical Safety Evaluation of Biopharmaceuticals: A Science-Based Approach to Facilitating Clinical 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-saving questions, Finish a procedure in many steps, Differentiate between various ideas.

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

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

Mapping with Programme Outcomes:

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

Core Project	**23PBIOD43: Project with Viva-Voce**	**Credit**	**7**
II Year		**Hours Per Week**	**10**
IV Semester			

(Refer to the Regulations)

Elective – VI	**23PBIOE44: Bio-safety, Lab Safety and IPR**	**Credit**	**3**
II Year		**Hours/ Week**	**4**
IV Semester			

Pre-requisites, if any:	The student should have a basic knowledge of hazards associated with the handling of biological agents and importance of intellectual property from scientific research.
Course Objectives	1. To assimilate the hazards associated with the handling of biological and chemical agents. 2. To understand how to protect from the hazards by the implementation of various safety measures in biochemical laboratories. 3. To implicate the importance of protecting the scientific intellect by filing patent and understand the various offices for filing and maintaining patents 4. To understand the scope of patenting in biological research. 5. To create an awareness of ethics associated with used of genetically modified organisms/cells and its rationale for use in living organisms.
Course Outcomes	After completion of the course, the students should be able to: **CO1.**To understand and implement various aspects of biosafety and carry out risk assessment of products in biological research **CO2. U**nderstand the basic concepts of ethics and safety that are essential for different disciplines of science and procedures involved and protection of intellectual property and related rights. **CO3.** To appreciate the intellectual property rights and its implementation of on the invention related to biological research. **CO4.** To understand the statutory bodies that regulate the property rights and its validity in various countries. **CO5.** Critique the ethical concerns associated with modern biotechnology processes and plan accordingly.
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.,

Method of Evaluation:

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

Methods of assessment:

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

Mapping with Programme Outcomes:

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

Skill Enhancement Course - III	**23PBIOS45: Developmental Biology**	**Credit**	**2**
II Year		**Hours/ Week**	**4**
IV Semester			

Pre-requisites, if any:	Comprehensive Knowledge of Cell Biology
Course Objectives	The candidates undertaking this course will understand the concepts of developmental biology. 1. To understand the background of developmental biology 2. To gain in-depth knowledge of various model organisms 3. To gain insight into aspects of stem cell technology 4. To gain insights into morphogenesis and oranogenesis 5. To acquire in-depth understanding of cell death mechanisms and cell fate decision
Course Outcomes	**CO1**.Grasp knowledge about the background of developmental biology **CO2**.Gain abundant knowledge about model oraganisms and gametogenesis **CO3**.Gain knowledge about stem cells and their applications in regenerative therapy **CO4**.Good knowledge about organogenesis **CO5**.Learn the basics of cell death mechanisms and cell fate decision .
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. Drosophila Developmental biology- Axis formation, Genes & mutation. *C.elegans* – 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 Drosophila, amphibia and chick; organogenesis – vulva formation in Caenorhabditis elegans, eye lens formation, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.
V	Cellular senescence and Cell fate decision Cellular senescence – concepts & Frizzled receptor in Development and disease. Diabetes and developmental biology, Cell death pathways in development~~s~~. Markers of important diseases.
Reading List (Print and Online)	Developmental Biology – Gilbert Scott http://bgc.org.in/pdf/study-material/developmental-biology-7th-ed-sf-gilbert.pdf
Recommended Texts	Developmental biology: VIII edition, **Gilbert, S**F; Sinauer Associates, Inc

Method of Evaluation:

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

Methods of assessment:

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

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

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

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

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

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

Mapping with Programme Outcomes:

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

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

S-Strong M-Medium L-Low

Method of Evaluation:

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

Methods of assessment:

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

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

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

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

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

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

Mapping with Programme Outcomes:

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

S-Strong M-Medium L-Low

Extension Activity	**23PBIOX46: Extension Activity**	**Credit**	**1**
II Year		**Hours/ Week**	**-**
IV Semester			

(Refer to the Regulations)

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