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| **C:\Users\admin\Pictures\AUlogo.pngANNAMALAI 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)   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | **Part** | **Course Code** | **Study Components & Course Title** | **Credit** | **Hours/ Week** | **Maximum Marks** | | | | **CIA** | **ESE** | **Total** | |  |  | **SEMESTER – I** |  |  |  |  |  | | Part 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 | |  | Elective – I | 3 | 5 | 25 | 75 | 100 | | 23PBIOE14-1 | Physiology & Cell Biology (To include Hormones) |  |  |  |  |  | | 23PBIOE14-2 | Developmental Biology |  |  |  |  |  | |  | Elective-II | 3 | 5 | 25 | 75 | 100 | | 23PBIOE15-1 | Microbiology and Immunology |  |  |  |  |  | | 23PBIOE15-2 | Plant Biochemistry |  |  |  |  |  | |  |  | **Total** | **20** | **30** |  |  | **500** | |  |  | **SEMESTER – II** |  |  |  |  |  | | Part 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 | |  | Elective – III | 3 | 4 | 25 | 75 | 100 | | 23PBIOE24-1 | Clinical Biochemistry |  |  |  |  |  | | 23PBIOE24-2 | Research Methodology |  |  |  |  |  | |  | Elective – IV | 3 | 4 | 25 | 75 | 100 | | 23PBIOE25-1 | Energy and drug metabolism |  |  |  |  |  | | 23PBIOE25-2 | Bioinformatics |  |  |  |  |  | | Part B | 23PBIOS26 | Skill Enhancement Course (SEC-I):  Organic farming | 2 | 4 | 25 | 75 | 100 | |  |  | **Total** | **22** | **30** |  |  | **600** | |

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

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| **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 biological processes will be understood. 3. The structure, properties and biological significance of lipids in the biological system will be studied 4. Students will learn about the concepts of protein structure and their significance in biological processes and creatively comprehend the role of membrane components with their biological significance. 5. Students will gain knowledge about the structures and functional roles of nucleic acids in the biological system |
| **Course Outcomes** | 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 in Signalling 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-cell interactions.(K3,K4)  **CO5.** Applying the knowledge of nucleic acid sequencing in research and diagnosis (K2, K3,K4) |

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| **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\_Bioc hemistry\_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) Lehninger Principles of Biochemistry (6th ed) W.H. Freeman. 2. Voet.D & 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. Lubert Stryer (2010) Biochemistry,(7th ed), W.H.Freeman 6. Satyanarayan,U (2014) Biochemistry (4th ed), Arunabha Sen Books & Allied (P) Ltd, Kolkata. | |

**Method of Evaluation:**

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| 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:**

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|  | **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

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

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| **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:**

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| --- | --- | --- | --- | --- | --- |
| 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:**

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

**S-Strong MS-Strong M-Medium L-Low**

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

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| **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\_Bio chemistry\_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) |

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| 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:**

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|  | **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**

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| **Semester** | **23PBIOE14-1: Elective – 1 (Discipline centric)**  **PHYSIOLOGY AND CELL BIOLOGY ( TO include Hormones)** | **H/W** | **C** |
| **I** | **5** | **3** |

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| **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:**

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| 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:**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **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**

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

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| **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:**

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| --- | --- | --- | --- | --- | --- |
| 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:**

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|  | **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**

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| **Semester** | **23PBIOE15-1: Elective – II (Discipline centric)**  **MICROBIOLOGY & IMMUNOLOGY** | **H/W** | **C** |
| **I** | **5** | **3** |

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| **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.fronti](http://www.frontiersin.org/articles/10.3389/fphar.2020.578970/full#h9)e[rsin.org/articles/10.3389/fphar.2020.578970/full#h9](http://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/](about:blank) | |
| **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:**

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| --- | --- | --- | --- | --- | --- |
| 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:**

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|  | **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**

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

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| **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:**

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| --- | --- | --- | --- | --- | --- |
| 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

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|  | **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**

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

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| **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) |

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| **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:**

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| --- | --- | --- | --- | --- | --- |
| 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:**

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|  | **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**

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

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| **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\_Sulf ur\_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:**

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| --- | --- | --- | --- | --- | --- |
| 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:**

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|  | **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**

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

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| **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 actual need 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:**

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| 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:**

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|  | **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**

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

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| **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](https://www.healthline.com/health/hyperphosphatemia) or [hypophosphatemia](https://www.healthline.com/health/hypophosphatemia);  Clinical significance: Potassium: [hyperkalaemia](https://www.healthline.com/health/high-potassium-hyperkalemia) and hypokalaemia, Sodium:  [hypernatremia](https://www.healthline.com/health/hypernatremia) and [hyponatremia](https://www.healthline.com/health/hyponatremia); Chloride: [hyperchloremia](https://www.healthline.com/health/hyperchloremia), [hyporchloremia](https://www.healthline.com/health/hyperchloremia)  **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-   1. **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:**

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

**Methods of assessment:**

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**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:

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|  | **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**

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

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| **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](http://www.research.org)  [www.pubmed](http://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**

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| **Semester** | **23PBIOE25-1 :**  **ELECTIVE PAPER–IV (Generic centric)**  **ENERGY AND DRUG METABOLISM** | **H/W** | **C** |
| **II** | **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 G  2. Interrelationship of carbohydrate, protein, and fat metabolism-role of acetyl CoA |
| **Recommended**  **Texts** | 1.David L.Nelson and Michael M.Cox (2012) Lehninger Principles of Biochemistry (6th ed), W.H.Freeman  2. Robert K. Murray, Darryl K. Granner, Peter A. Mayes, and Victor W. Rodwell (2012), Harper's Illustrated Biochemistry, (29th ed), McGraw-Hill Medical  3. Metzler D.E (2003). The chemical reactions of living cells (2nd ed), Academic Press.  4. Zubay G.L (1999) Biochemistry , (4th ed), Mc Grew-Hill.  5. Devlin RM (1983) Plant Physiology (4th ed), PWS publishers  6.Taiz L , Zeiger E (2010), Plant Physiology (5th ed), Sinauer Associates, Inc |

**Method of Evaluation:**

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

**Methods of assessment:**

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

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

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

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

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

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

**Mapping with Programme Outcomes:**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **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**

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

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| **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](http://www.pubmed)  [www.ncbi.nlm.org](http://www.ncbi.nlm.org)  [www.fasta](http://www.fasta)  [www.blast](http://www.blast) |
| **Self-Study** | 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:**

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|  | **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**

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

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| **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 |

|  |  |
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| **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 managemen**t  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](http://www.crri).  nic.in [www.drrindia.org](http://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:**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **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**

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