

Master of Science  
in  
Biochemistry

Course Structure and Syllabus

For students admitted from academic year 2022-23 onwards

UNDER CHOICE BASED CREDIT SYSTEM (CBCS) & OUTCOME BASED EDUCATION (OBE)

(Regulations:R22)



DEPARTMENT OF BIO-CHEMISTRY

KRISHNA UNIVERSITY

Machilipatnam – 521 004

Andhra Pradesh

## VISION

- ❖ To strive for all round development of students for attainment of scientific empowerment both in teaching and research and self-reliant as well.
- ❖ To establish multi-institutional, interdisciplinary and international collaborations in Thrust areas of scientific research so as to acquire national and international recognition.
- ❖ To develop advanced characterization facilities for cutting edge research with a Roadmap towards the establishment of Centre for Biochemical Analysis.
- ❖ To strive for transformation of laboratory research towards industrial scale so as to acquire industrial collaboration and funding as well.

## MISSION

- ❖ Dissemination of knowledge through research-based teaching and learning processes with a motive to inculcate strong research attitude in student community.
- ❖ Build good character and educate students so as to become enlightened individuals, improving the living standards of their families and society.

## PROGRAMME OBJECTIVES

The objective of the course has therefore been to consolidate students training in Biochemistry and other integrated sciences and encourage them to develop intellectual independence, critical thinking skills and versatility for problem solving in Biochemistry and other related courses. This and the core values have been the guiding principle of the research programmes.

The Biochemistry Programme has pursued its curriculum and research agenda in recognition of the role of Biochemistry in contributing to both basic life sciences and applied research in industries.

The major objectives of M.Sc., Biochemistry course are,

PO1-To study the structures and functions of various biomolecules of biological importance .

PO2-To understand the principles, instrumentation and applications of analytical techniques.

PO3-To study the principles of enzyme catalysis, bioenergetics and major metabolic pathways.

PO4-To study the expression of molecular genes and molecular techniques.

PO5- To understand human physiology and nutritional requirements.

PO6- To study molecular concepts of body defenses and its mechanisms.

PO7- To impart knowledge in principles and applications of clinical Biochemistry.

PO8-To obtain knowledge in Pharmaceutical, Microbial and Industrial Biochemistry.

PO9-To acquire skills for laboratory experiments.

PO10-To prepare candidates for a career in Pharmaceutical industries, food industries etc.

#### PROGRAMME OUTCOMES (Pos)

POs1 Disciplinary knowledge Students will apply the scientific knowledge acquired in Life Sciences and become skilled professionals adhering to the values of sustainable living.

POs 2 Communication Skills, Teamwork and leadership qualities Students will enhance their communication skills to develop an attitude to work as a team and hone leadership qualities.

POs 3 Critical thinking, problem-solving and analytical reasoning Students will demonstrate analytical reasoning, problem-solving, scientific reasoning, and reflective thinking as professionals in all frontiers of life sciences.

POs 4 Research-related skills and Scientific reasoning Students will develop and popularize scientific temper to make conceptual contributions in life sciences and promote environmental consciousness.

POs 5 Skill development, entrepreneurship and lifelong learning Students will develop skills, tools and techniques to explore prospective avenues of entrepreneurship in emerging areas of life sciences and pursue lifelong learning.

POs 6 Environment and ethical awareness Students will understand and contextualize environmental and ethical issues and contribute towards the betterment of the environment and sustainable growth.

POs 7 Digital literacy and self-directed learning Students will engage in self-paced and self-directed lifelong learning through digital literacy for personal development and professional accomplishment.

**COURSE STRUCTURE AND REQUIREMENTS FOR M.Sc. BIOCHEMISTRY  
(REGULATION: R22)**

1	Title of the Program	M.Sc. BIOCHEMISTRY
2	Duration of the Program	2 years (Four Semesters)
3	Eligibility criteria for admission	The candidate seeking admission into M.Sc. Biochemistry Program should have passed Bachelor's Degree Examination not less than three years duration in any discipline with Biochemistry as one of the subjects and biological sciences at 10+2 level.
4	Level of the Program	Post Graduate.
5	Mode of Admission	The mode of admission is through APPGCET conducted by Andhra Pradesh State Council of Higher Education or KRUCET conducted by Krishna University.
6	Objectives of the Program	The Objective of M.Sc. Biochemistry Program is to impart knowledge in basic concepts in core areas of Biochemistry as well as recent advances in Biochemistry, training in experimental skills with an aim to develop research in commercial and scientific applications.
7	Program requirements	The Program shall include theory (core as well as non-core, open electives, specializations) papers, Laboratories, Tests, Seminars and Project Work.
8	Number of working days	In each semester at least ninety (90) working days must be dedicated for theory classes, practical classes seminars and project work.



**KRISHNA UNIVERSITY::MACHILIPATNAM**  
**COURSE STRUCTURE FOR M.Sc. BIOCHEMISTRY**

**UNDER CHOICE BASED CREDIT SYSTEM (CBCS) & OUTCOME BASED EDUCATION (OBE)**

**W.E.F 2022-23 (R22 Regulations)**

**I SEMESTER**

Course Code	Course Name	Teaching Hours/ week			CORE/ IDC/ DSE/SEC/ OEC/MOCS	Internal Marks	External Marks	No. of Credits
		Lecture	Practical	Tutorial				
22BIC101	Molecules of life (Biomolecules)	4	0	0	Core	30	70	4
22BIC102	Cell Biology	4	0	0	Core	30	70	4
22BIC103	Genetics	4	0	0	Core	30	70	4
22BIC104	Microbial Biochemistry Molecular Physiology	4	0	0	Core	30	70	4
22 BIC 105 COMPULSORY	Personality Development through Life Enlightenment Skills	3	1	0	Core	30	70	3
22BICL101	Biochemistry Laboratory - I	0	6	0	Core	30	70	3
22BICL102	Biochemistry Laboratory - I	0	6	0	Core	30	70	3
<b>TOTAL FOR FIRST SEMESTER</b>						<b>210</b>	<b>490</b>	<b>25</b>

**II SEMESTER**

Course Code	Course Name	Teaching Hours/ week			CORE / IDC/DSE/ SEC/OEC/MO OCS	Internal Marks	External Marks	No. of Credits
		Lecture	Practical	Tutorial				
22BIC201	Bioinstrumentation & Bioanalytical Techniques	4	0	0	Core	30	70	4
22BIC202	Enzymology	4	0	0	Core	30	70	4
22BIC203	Intermediary Metabolism	4	0	0	Core	30	70	4
22BIC204 COMPULSORY	Research Methodology & IPR	3	1	0	SEC	30	70	3
<b>DOMAIN SPECIFIC ELECTIVE COURSES (CHOOSE ANY ONE)</b>								
22BICDSE201	Molecular Biology	4	0	0	DSE	30	70	4
22BICDSE202	Bioprocess Technology	4	0	0	DSE	30	70	4
22BICDSE203	Thermodynamics & Bioenergetics	4	0	0	DSE	30	70	4
<b>LAB PRACTICALS</b>								
22BICL201	Biochemistry Laboratory - III	0	6	0	Core	30	70	3
22BICL202	Biochemistry Laboratory - IV	0	6	0	Core	30	70	3
<b>TOTAL FOR SECOND SEMESTER</b>						<b>210</b>	<b>490</b>	<b>25</b>

At the end of 2<sup>nd</sup> semester, every student must undergo summer Internship/ Apprenticeship/Project work/Industrial training/research-based Project work for Six weeks and must prepare a report concerned as per approved project guidelines and submit the same to the University 14 days before the commencement of third semester end examinations.

### III SEMESTER

Course Code	Course Name	Teaching Hours/ week			CORE/ IDC/ DSE/SEC/ OEC/MOOCs	Internal Marks	External Marks	No. of Credits
		Lecture	Practical	Tutorial				
22BIC301	Immunology and Immune Technology	4	0	0	Core	30	70	4
<b>DOMAIN SPECIFIC ELECTIVE COURSES (CHOOSE ANY THREE)</b>								
22BICDSE301	Biostatistics & Bioinformatics	4	0	0	DSE	30	70	4
22BICDSE302	Genetic Engineering	4	0	0	DSE	30	70	4
22BICDSE303	Stem Cell Technology	4	0	0	DSE	30	70	4
22BICDSE304	Virology	4	0	0	DSE	30	70	4
22BICDSE305	Plant Biochemistry	4	0	0	DSE	30	70	4
22BICDSE306	Scientific writings & Bioethics	4	0	0	DSE	30	70	4
<b>LAB PRACTICALS</b>								
22BICL301	Biochemistry Laboratory - V	0	6	0	Core	30	70	3
22BICL302	Biochemistry Laboratory - VI	0	6	0	Core	30	70	3
<b>OPEN ELECTIVE (INTERDISCIPLINARY/MULTIDISCIPLINARY) COURSES (CHOOSE ANY ONE)</b>								
22BICOEC301	Biomaterials	3	0	0	OEC	30	70	3
22BICOEC302	Biomolecules of Life	3	0	0	OEC	30	70	3
22BICOEC303	Lifestyle Associated Diseases and prevention	3	0	0	OEC	30	70	3
<b>TOTAL FOR III SEMESTER</b>							490	25

### IV SEMESTER

Course Code	Course Name	Teaching Hours/ week			CORE / IDC/ DSE/SEC/ OEC/MOOCs	Internal Marks	External Marks	No. of Credits	
		Lecture	Practical	Tutorial					
22BIC401	Clinical Biochemistry	4	0	0	Core	30	70	4	
<b>DOMAIN SPECIFIC ELECTIVE COURSES (CHOOSE ANY THREE)</b>									
22BICDSE401	Development Biology	4	0	0	DSE	30	70	4	
22BICDSE402	Biopharmaceutics	4	0	0	DSE	30	70	4	
22BICDSE403	Nutritional Biochemistry	4	0	0	DSE	30	70	4	
22BICDSE404	Cancer biology	4	0	0	DSE	30	70	4	
22BICDSE405	Endocrinology	4	0	0	DSE	30	70	4	
22BICDSE406	Environmental Biochemistry	4	0	0	DSE	30	70	4	
<b>LAB PRACTICALS</b>									
22BICL401	Laboratory Course - VII	0	6	0	Core	30	70	3	
<b>ENTREPRENURAL &amp; INNOVATION/IT SKILL RELATED TO DOMAIN SPECIFIC ELECTIVE COURSES (CHOOSE ANY ONE)</b>									
22BICSEC401	Blood Bank Technology	3	0	0	SEC	30	70	3	
22BICSEC402	Hospital Management & Medical Transcription	3	0	0	SEC	30	70	3	
22BICSEC403	Biomedical instrumentation	3	0	0	SEC	30	70	3	
<b>* CHOOSE MOOCs FROM SWAYAM/NPTEL SOURCES</b>									
22 BIC MOOCs 401								4	
22 BICP401	PROJECT WORK EVALUATION AND VIVA-VOCE					100		4	
<b>TOTAL FOR IV SEMESTER</b>							180	520	30

Note: Students may be allowed to register and appear for MOOCs from the third semester itself. However, students are to complete the MOOCs successfully and submit pass

certificate of the same to the University through the Principal of the College concerned for approval and endorsement of the same on grade cards and PCs and Ods as per the regulations of the University.

#### 22BICP401:PROJECT WORK EVALUATION AND VIVA-VOCE

A). Research activity: A short research activity on any significant or interesting aspects of the works(preferably relevant to the students' field of study/specialization) has to be performed or observed by a student in the organization. As part of curriculum students are required to write a short report generally named as a Research activity under the guidance of supervisor.

#### B). Purpose of Research activity:

The basic purpose of writing a Research activity is to allow students to explore the breadth of research that is performed within the organization. For students, this breadth of exposure to outside research may prove fruitful as a platform for their own research at some later point(can be extended to as a thesis topic for Ph.D. degree) and also for career connections /employment opportunities prior to post-graduation through demonstrating their competences in research techniques. It is up to the student to choose/select the title/topic for Research activity from any interesting aspects of their duties they are involved. However, the supervisor may also assist the student in selecting the Research Activity Report title that can satisfy him/her expectation as well as it is related to the student's fields of study. It is expected that the supervisor stays in regular contact with the student for monitoring and checking the smooth progress of the research activity and assuring and contributing to the assessment. Supervisor is expected to provide feedback on student performance to the HoD.

#### C). Project Evaluation:

Out of a total of 100 marks, 20 marks for Pre-Project Review, 50 marks shall be for Project report/dissertation/record and 30 marks for the End Semester Examination (Viva-voce). The Viva-Voce shall be conducted by a committee consisting of HOD, Project Supervisor and an Examiner nominated by the University.



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W.E.F 2022-23 (R22 Regulations)

**I SEMESTER**

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		Lecture	Practical	Tutorial				
22BIC101	Molecules of life (Biomolecules)	4	0	0	Core	30	70	4
22BIC102	Cell Biology	4	0	0	Core	30	70	4
22BIC103	Genetics	4	0	0	Core	30	70	4
22BIC104	Microbial Biochemistry & Molecular Physiology	4	0	0	Core	30	70	4
22 BIC 105	Personality Development through Life Enlightenment Skills	3	1	0	Core	30	70	3
22BICL101	Biochemistry Laboratory - I	0	6	0	Core	30	70	3
22BICL102	Biochemistry Laboratory - II	0	6	0	Core	30	70	3
<b>TOTAL FOR FIRST SEMESTER</b>						<b>210</b>	<b>490</b>	<b>25</b>



**KRISHNA UNIVERSITY, MACHILIPATNAM –521003**

**DEPARTMENT OF BIOCHEMISTRY**

**M.Sc Biochemistry, I-SEMESTER**

Course Name	Fundamentals of Biomolecules	L	T	P	C	IM	EM	TM
Course code	22BIC101	0	4	0	4	30	70	100

L-Lecture, T-Tutorial, P-Practical, C-Credits, IM-Internal Marks, EM-External Marks,  
TM-Total Marks

**Course Objective:**

- Gives information about classification, physico-chemical properties of amino acids and structural organization of proteins.
- To understand the structure, properties and biological importance of carbohydrates and lipids.
- Explore the composition and structure of nucleic acids

**Course Outline:**

**UNIT - I : Introduction**

Structure of atoms, molecules and chemical bonds. Physical properties and structure of water, hydrogen bonding, solvent properties of water, ionization of water, fitness of aqueous



environment for living organisms

Carbohydrates–Classification, structure, general properties and functions of polysaccharides and complex carbohydrates; amino sugars, proteoglycans and glycoproteins. bacterial cell wall polysaccharides, blood group substances and sialic acids.

#### UNIT - II : Amino Acids & Proteins

Structure and properties of amino acids, essential and non-essential amino acids, general reactions of amino acids.

Classification of proteins on the basis of solubility and shape, structure (Primary, Secondary, Tertiary and Quaternary), and biological functions. Denaturation and renaturation of proteins. Structure of collagen and hemoglobin.

#### UNIT - III: Lipids:

Classification, structure, properties and functions of fatty acids, essential fatty acids, fats, phospholipids, sphingolipids, cerebrocides, steroids, bile acids, prostaglandins, lipoamino acids, lipoproteins, proteolipids, phosphatidopeptides, lipopolysaccharides.

#### UNIT- IV: Nucleic Acids

DNA: Structure, physical and chemical properties, DNA topology (Supercoil forms of DNA, Linking number), Structural organization of DNA, Types of DNA -A, B, Z, forms of DNA, Satellite DNA, Centromeric DNA

RNA: Structure, physical and chemical properties of RNA and types (mRNA, tRNA, rRNA, hnRNA, snRNA)

#### UNIT – V: Heterocyclic systems

Occurrence in biological systems, structure and properties of Furan, Pyrrole. Indole, Thiazole, Imidazole, Pyridine, Pyrimidine, Purine, Quinine, Pteridine and Isoalloxazine. Chemistry of porphyrins (chlorophyll heme, myoglobin and cytochrome.

#### Books recommended:

1. Lubert Stryer, W.H. Freeman, 1995 - Biochemistry 5 th Edition .
2. Richard A. Harvey (Ph. D.), Richard A. Harvey, Denise R. Ferrier Lippincott Williams & Wilkins, 2011 Biochemistry,
3. Alexander Thomas Cameron, 1928 Textbook of Biochemistry, 1st edition.
4. Fundamentals of Biochemistry by Donald Voet, Judith Voet and Pratt, second edition, 1995
5. Robert K. Murray David Bender Kathleen M Botham, Peter J. Kennelly Victor W. Rodwell , P. Anthony Weil, , 2015, Harpers Illustrated Biochemistry 30th Edition.
6. Principle of Biochemistry - Lehninger Latest Edition 7. Biochemistry – Zubey (2nd Edition).

#### Expected Course Outcomes:

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

- ❖ H-bonding, acids and bases, reaction equilibrium, ionization behavior and its biological application.
- ❖ Relate the role Carbohydrates in energy production and living systems [K1, K2, K3]
- ❖ Apply the link between the structure and functions of aminoacids and proteins in biological context [K1, K2, K3]
- ❖ Explain the structure, properties and roles of lipids in biological system. [K2, K3, K4]

- ❖ Relate the structure of lipids with their reactivity in biological membrane systems and life processes. [K3, K4]
- ❖ Apply the structural studies to the biological processes like replication, transcription and translation [K3, K4]

\*\*\*K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create



KRISHNA UNIVERSITY, MACHILIPATNAM –521003

DEPARTMENT OF BIOCHEMISTRY

M.Sc Biochemistry, I-SEMESTER

Course Name	Cell Biology	L	T	P	C	IM	EM	TM
Course Code	22BIC 102	4	0	0	4	30	70	100

L-Lecture, T-Tutorial, P-Practical, C-Credits, IM-Internal Marks, EM-External Marks,  
TM-Total Marks

#### ❖ Course Description and Purpose:

The focus of Cell Biology is the study of the structure and function of the cell. In this course we will focus on Eukaryotic cell biology and will cover topics such as membrane structure and composition, transport, and trafficking; the cytoskeleton and cell movement; the breakdown of macromolecules and generation of energy; and the integration of cells into tissues. We will also cover important cellular processes such as cell cycle regulation, signal transduction, apoptosis (programmed cell death), and cancer cell biology.

#### ❖ Course Learning Objectives:

- To make the learners understand the functional aspects of the cell at molecular level.
- To focus on the up-coming molecular mechanisms involving the membrane organization and signal transduction.
- To understand the inheritance pattern at molecular level.

#### ❖ Course Content

##### UNIT – I: Structure and Functions of Cells

Discovery of the cell and the cell theory, exceptions to the cell theory. Cell shape, cell size and cell number. Prokaryotic vs eukaryotic cells. Cell motility in prokaryotes and eukaryotes by cilia and flagella. Chemotaxis and Quorum sensing. Cytoskeleton: microtubules, actin filaments and intermediate filaments.

##### UNIT – II: Structure and Function of Major Cellular Organelles

Structure and function of cell wall, plasma membrane, endoplasmic reticulum, Golgi apparatus, lysosomes, peroxisomes, mitochondria and chloroplast. Structure and role of ribosomes.

##### UNIT – III: Nucleus and Chromatin

Structure and function of nuclear membrane. Organization of nuclear material in prokaryotes

and eukaryotes. Eukaryotic chromosome – Histone proteins and nucleosomes. Organization of metaphase chromosome in eukaryotes. Chromosome banding pattern, polytene and lamp brush chromosomes. Organization of nucleolus.

#### UNIT – IV: Cell cycle, apoptosis and cancer

Phases of cell cycle- Regulation of cell cycle: Discovery of MPF, cyclins and cyclin dependent kinases, Check points- role of Rb and p53, Cell division by mitosis and meiosis.

Apoptosis- Neurotrophic factors, caspases, Pathways of apoptosis.

Cancer- Types and stages of cancer, characteristics of cancer cell, carcinogenesis, carcinogens, oncogenes, Tumor suppressor genes and protooncogenes, Molecular basis of cancer, cell senescence.

#### UNIT – V: Cell –Cell Interactions and Signaling

Cell to cell interaction – Microvilli, tight junctions, gap junctions, desmosomes. Cell adhesion and cell signaling (autocrine, paracrine, synaptic and endocrine). Second messengers – Types and mechanism of action.

#### Books recommended:

1. Verma P.S and Agarwal V.K. 2006. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. S. Chand & Company Ltd
  2. Lewin B. 2008. Genes IX. Jones and Bartlett publishers
  3. Satyanarayana U. 2007. Biotechnology. Books and allied (P) Ltd
  4. Darnell J, Lodish H and Baltimore D 1986. Molecular Cell Biology. Scientific American Books.
  5. Watson JD, Hopkins NH, Roberts JW et al. 1987. Molecular Biology of the Gene (4th ed.) The Benjamin/Cummings Publishing Company, Inc.
  6. Tamarin RH. 1999. Principles of Genetics (6th Ed.) WCB McGraw-Hill.
  7. Karp G. 1998. Cell and Molecular Biology (2nd Ed.) John Wiley and Sons, Inc.
  8. Lodish H, Berk A, Matsudaira P et al 2004. Molecular Cell Biology (5th ed.) W.H. Freeman and Company, New York.
  9. Becker MW, Kleinsmith LJ and Hardin J. 2007. The world of the Cell (6th Ed.) Tata McGrawHill Publications.
  10. Raven PH, Johnson GB, Losos JB and Singer SR. 2006. Biology (7th Ed.) Tata McGrawHill Publications.
- Smith & Wood, Cell Biology, 2nd Edition, Chapman & Hall, London, 1996.

#### Expected Course Outcomes:

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

- ❖ To understand and recall the basic structure, origin and development of cell organelles. [K1, K2, K3]
- ❖ To integrate and assess the biochemical, cytological and histological tools to infer cellular basis of organization. , K2]
- ❖ To analyze and differentiate organisms based on structure, composition and inter and intra cellular interactions. [K1, K2]
- ❖ To explain the role of cells and cell organelles in various biological processes. [K1, K2]
- ❖ To construct and simulate the role of different cytological tools to explain the structure and complexity of cells and cell organelles. [K2]

\*\*\*K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create



KRISHNA UNIVERSITY, MACHILIPATNAM –521003

DEPARTMENT OF BIOCHEMISTRY

M.Sc Biochemistry, I-SEMESTER

Course Name	Genetics	L	T	P	C	IM	EM	TM
Course Code	22BIC 103	4	0	0	4	30	70	100

#### ❖ Course Description and Purpose:

This course provides an introductory overview of major and timely topics in genetics. The objective is to provide students with a broadly-based and fundamental understanding of genetics, and to present selected challenges and issues that currently face the genetics research and communities. This course provides students with an understanding of the principles and concepts of genetics and introduces transmission, nature and action of genetic material in organisms.

#### ❖ Course Learning Objectives:

- Use the principles of chromosome transmission to predict patterns of inheritance.
- Evaluate scientific data using the rules of probability.
- Understand how the structure of DNA enables it to function as genetic material.
- Explain the relationship between genotype and phenotype.
- Understand the molecular basis of mutation, and its role in genetic variation.
- Explain how the genetic code enables protein synthesis to be directed by genetic information.
- Understand how genomes are replicated, repaired, organized and packaged.
- Describe the modes of gene regulation in prokaryotes and eukaryotes.
- Use a computer to search public databases and manage bibliographic information.

#### ❖ Course Content:

##### UNIT – I: Mendelian Laws of Inheritance

Mendel's laws – Monohybrid and dihybrid cross. Test cross and back cross. Sex chromosomes and determination. Sex-linked inheritance. Linkage and crossing over. Interference. Recombination frequency. Numerical changes in chromosomes – euploidy, haploidy, and their fundamental and practical significance. Polyploidy – induction. Aneuploidy – type and genetic significance. Population genetics – Hardy and Weinberg law.

##### UNIT – II: Nature of Genetic Material

Evidence to prove DNA and RNA as genetic material. Gene as a unit of expression. Colinearity of gene and polypeptide. Modern concept of gene. Fine structure analysis of rII locus of T4 bacteriophage – Establishment of recon, muton and cistron. Complementation test. Types of genes – Pseudogenes, House-keeping genes, homeotic genes and regulatory genes.

##### UNIT – III: Plasmids and Transposons

Plasmids: Types, copy number, replication, amplification and curing. Regulation of col E1 plasmid replication. Methods of plasmid transfer – Microinjection, electroporation, calcium chloride treatment, triparental mating.

Transposons: Types of bacterial transposons - insertional sequences, complex transposons. Retroposons. Transposons of eukaryotes – Copia, P3 and TY elements. Mechanism of transposition – Replicative and non-replicative.

#### UNIT – IV: Genetic Recombination in Bacteria

Genetic recombination in bacteria. Models of genetic recombination (Break-join, Copy-choice, Break- copy). Role of recA protein. Genetic transfers in bacteria. Discovery and mechanism of transformation. Discovery and mechanism of Transduction (generalized, specialized and abortive). Discovery of sex among bacteria. Genetic transfer by Conjugation ( $F^+$  and  $F^-$ ,  $F'$  and  $F^-$  (sexduction), and Hfr and  $F^-$ ). Mapping of bacterial chromosome by genetic recombination, transformation, conjugation and transduction.

#### UNIT – V: Mutations and Mutagenesis

Mutations and mutagenesis: Types of mutations, Mutagenic agents, Molecular basis of mutations, Mechanism of Mutagenesis. Transposon mutagenesis, Site-directed mutagenesis and their applications. Evaluation of mutagens by Ames test and micro nuclei test. Thymine dimerization. Repair of T-dimers: Photo-reactivation, Excision repair, Post-replication, Recombination and SOS repair mechanisms. Heat- shock and adaptive responses, role of recA in DNA repair.

#### Books Recommended:

1. Cell Biology : DeRobertis and DeRobertis
2. Molecular biology of cell: B.Alberts et al Cell
3. Molecular biology: G.Karp
4. Molecular Biology of the cell: J.D.Watson et al
5. Genes VII: B.Lewin
6. Lehninger's Principles of Biochemistry: Nelson and Cox. Biochemistry: L.Stryer
7. Biochemistry: Voet and Voet.

#### Expected Course Outcomes:

On successful completion of the course, the student shall be able to:

- ❖ Classical and modern concepts in genetics, molecular and developmental genetics, mapping techniques, Mendelian genetics, genetic fine structure.
- ❖ basic principles of genetics, gene linkage and X-linked inheritance and cytoplasmic inheritance
- ❖ Various causes of mutation and their repair mechanism [K1, K2]
- ❖ The mechanism of various gene transfer methods [K1, K2, K3]

\*\*\*K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create



KRISHNA UNIVERSITY, MACHILIPATNAM –521003

DEPARTMENT OF BIOCHEMISTRY

M.Sc Biochemistry, I-SEMESTER

Course Name	Microbial Biochemistry & Molecular Physiology	L	T	P	C	IM	EM	TM
Course Code	22BIC 104	4	0	0	4	30	70	100

L-Lecture, T-Tutorial, P-Practical, C-Credits, IM-InternalMarks, EM-ExternalMarks, TM- TotalMarks

#### ❖ Course Description and Purpose:

This course provides the basic information on the structural and metabolic diversity of microorganisms. To familiarize students with different conditions and requirements associated with microbial growth and reproduction. This course spot lights on microbial metabolism, physiology, biochemistry and genetics.

#### ❖ Course Learning Objectives:

To make understand the

-Great biodiversity existing in the microbial world and relate the ecophysiological aspects of microorganisms to the functioning of the biogeochemical cycles that govern the terrestrial ecosphere.

-Know the possibilities of environmental application presented by the biotechnology of higher organisms.

#### ❖ Course Content

UNIT-I: Over view of prokaryotic cell

structure & functions Cell wall synthesis, flagella structure and synthesis, Exopolysaccharide synthesis.

Membrane transport in bacteria-simple, group translocation, ABC transporters, Protein exportin bacteria, Protein export pathways & Iron transport- siderophores.

UNIT-II: Overview of Microbial Physiology

Microbial Cell division machinery, Microbial Nutrition, Microbial Growth kinetics, Microbial Photosynthesis.

Stress Adaptations in thermophiles, halophiles, alkaliphiles, acidophiles, Extremophiles-adaptations & significance in biotechnology.

### UNIT – III: Two component signal transduction in prokaryotes

Chemotaxis, Quorum sensing & Biofilms, Sporulation inducing signals & events in sporulation. Osmolarity porin regulation in E.coli (Omp system) Phosphate assimilation in E.coli (Pho system), Nitrogen fixation in Rhizobium (Ntr system).

### UNIT-IV: Physiological Adaptations and Intercellular signaling

Regulation of gene expression & responses to changing environments Introduction to two component system, Regulatory systems sporulation in *Bacillus subtilis*, control of competence in *Bacillus subtilis*. Heat-Shock responses.

### UNIT-V: Microbial genetics

Recombination in prokaryotes, Transformation, conjugation, & transduction. Mapping of prokaryotic genes. Transposons, and mechanism of transposition. Biology of plasmids. Extra chromosomal inheritance.

### ❖ Books Recommended :

1. Text book of Microbiology by Pleczar and Reid (Mc Graw Hill).
2. Microbiology by Tortora, Funk & Case.
3. Microbiology by Prescott.
4. Genetics by M.W. Strickberger (Mac Millan).
5. Cell and Molecular Biology by E.D.P. DeRobertis (International edition).
6. Moat A.G. and Foster S.W. *Microbial Physiology* (4th Ed.) (2004). John Wiley and Sons, New York.
7. Stanier RY, Ingraham JI, Wheelis ML and Painter PR. *General Microbiology*. (5th Ed.) (1987). McMillan Press. UK.
8. Dubey RC and Maheswari DK. *A Text book of Microbiology*. (2005). S. Chand & Company Ltd., New Delhi.
9. Nelson D. L. & Cox M. M. *Lehninger's Principles of Biochemistry*, 4th edition. (2005). W. H. Freeman & Co. NY.
10. Pelczar Jr, M J, Chan E C S., Krieg N R, *Microbiology*, (5th Ed.), (2001). McGraw Hill Book Company, NY.

### Expected Course Outcomes:

On successfully completing the module students will be able to:

- ❖ Demonstrate comprehensive knowledge and understanding of the structural and metabolic diversity of microorganisms. [K1, K2]
- ❖ Demonstrate critical understanding of genetic biochemical and physiological regulation in microorganisms. [K1, K2]
- ❖ Demonstrate thorough knowledge and understanding of the experimental approaches used to investigate physiological and genetic control in microorganisms. [K1, K2]

\*\*\*K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create



KRISHNA UNIVERSITY, MACHILIPATNAM –521003

DEPARTMENT OF BIOCHEMISTRY

M.Sc Biochemistry, I-SEMESTER

Course Name	Personality Development through Life Enlightenment Skills	L	T	P	C	IM	EM	TM
Course code	22BIC105	0	3	1	4	30	70	100

L-Lecture, T-Tutorial, P-Practical, C-Credits, IM-Internal Marks, EM-External Marks, TM-Total Marks

### Course Objectives:

The Course will introduce the students to

- Become a person with stable mind, pleasing personality and determination.
- Learn to build positive attitude, self-motivation, enhancing self-esteem and emotional intelligence
- Learn to develop coping mechanism to manage stress through Yoga and meditation techniques

### Course outline:

#### UNIT – I: Introduction to Personality Development

The concept of personality - Dimensions of Personality – Theories of Personality development (Freud & Erickson) – The concept of Success and Failure – Factors responsible for Success –Hurdles in achieving Success and Overcoming Hurdles — Causes of failure – Conducting SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis.

#### UNIT – II: Attitude, Motivation and Self-esteem

Conceptual overview of Attitude – Types of Attitudes – Attitude Formation – Advantages/ Disadvantages of Positive/Negative Attitude - Ways to Develop Positive Attitude Concept of motivation: Definition and Nature of Motivation/Motive – Internal and external motives – Theories of Motivation – Importance of self- motivation- Factors leading to de- motivation. Self-esteem - Definition and Nature of self-esteem – Do's and Don'ts to develop positive self-esteem – Low self-esteem - Personality having low self-esteem - Positive and negative self-esteem.

#### UNIT – III: Other Aspects of Personality Development

Body language - Problem-solving - Conflict Management and Negotiation skills - Decision-making skills - Leadership and qualities of a successful leader – Character building -Team-work – Time management - Work ethics – Good manners and etiquette – Emotional Ability/Intelligence – Dimensions of Emotional Intelligence – Building Emotional Intelligence.



#### UNIT –IV:Neetisatakam-Holistic Development of Personality

Verses- 19,20,21,22 (wisdom) – Verses- 29,31,32 (pride and heroism) – Verses- 26,28,63,65 (virtue)

Personality of Role Model – Shrimad Bhagwadgeeta

Chapter2-Verses 17, Chapter 3-Verses 36,37,42 – Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

#### UNIT –V:Yoga & Stress Management

Meaning and definition of Yoga - Historical Perspective of Yoga - Principles of Astanga Yoga by Patanjali – Meaning and Definition of Stress - Types of Stress - Eustress and Distress –Stress Management – Pranayama- Pranayama: Anulom and Vilom Pranayama - Nadishudhi Pranayama– Kapalabhati-Pranayama - Bhramari Pranayama - Nadanusandhana Pranayama – Meditation techniques: Om Meditation - Cyclic meditation : Instant Relaxation technique (QRT), Quick Relaxation Technique (QRT), Deep Relaxation Technique (DRT) (Theory & Practical).

#### Books Recommended:

1. Hurlock, E.B. Personality Development, 28th Reprint. New Delhi: Tata McGraw Hill, 2006.
2. Gopinath,Rashtriya Sanskrit Sansthanam P, Bhartrihari”sThreeSatakam, Niti-sringar-vairagya, NewDelhi, 2010
3. Swami Swarupananda, Srimad Bhagavad Gita, AdvaitaAshram,Publication Department, Kolkata,2016.
4. Pravesh Kumar. All about Self- Motivation. New Delhi. Goodwill Publishing House. 2005.
5. Smith, B . Body Language. Delhi: Rohan Book Company. 2004
6. Yogic Asanas for Group Training - Part-I: Janardhan Swami Yogabhyasi Mandal, Nagpur.
7. Rajayoga or Conquering the Internal Nature by Swami Vivekananda, Advaita Ashrama (PublicationDepartment), Kolkata.
8. Nagendra H.R nadNagaratna R, Yoga Perspective in Stress Management, Bangalore, SwamiVivekananda Yoga Prakashan.

#### Online Resources:

[https://onlinecourses.nptel.ac.in/noc16\\_ge04/preview](https://onlinecourses.nptel.ac.in/noc16_ge04/preview)

<https://freevidelectures.com/course/3539/indian-philosophy/11>

#### Expected Course Outcomes:

- At the end of this course the students should be able to:
    - ❖ Develop their personality and achieve their highest goals of life. [K1, K2,K3,K4&K5]
    - ❖ Lead the nation and mankind to peace and prosperity.[ [K1, K2,K3,K4&K5]
    - ❖ Develop a positive approach to work and duties [K1, K2,K3,K4&K5]
- \*\*\*K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create



KRISHNA UNIVERSITY, MACHILIPATNAM –521003

DEPARTMENT OF BIOCHEMISTRY

M.Sc Biochemistry, I-SEMESTER

Course Name	Biochemistry Laboratory - I	L	T	P	C	IM	EM	TM
Course code	22BICL101	0	0	6	3	30	70	100

L-Lecture, T-Tutorial, P-Practical, C-Credits, IM-Internal Marks, EM-External Marks, TM-Total Marks

### List of experiments:

1. General reactions of carbohydrates. Specific reactions of different sugars: xylose, glucose, fructose, galactose, sucrose, maltose and lactose.
2. General reactions of proteins and amino acids. Precipitation reactions of albumins and globulins.
3. General reactions of lipids and cholesterol.
4. Determination of saponification number and acid value of oils and fats.
5. Isolation and estimation of glycogen
6. Isolation and estimation of starch.
7. Preparation of Casein from milk.
8. Titration curve of amino acid and calculation of PK and PI value.
9. Estimation of ascorbic acid (Vitamin C) in fruit juice by 2,4-Dinitrophenylhydrazine method
10. Determination of protein in given sample by Biuret method
11. Estimation of total amino acids by Ninhydrin method
12. Estimation of Total soluble sugars by anthrone method

### Books recommended:

1. Practical Biochemistry - K. Wilson & J. Walker (Cambridge Univ. Press)
2. Laboratory Manual in Biochemistry - J. Jayaraman (Narosa Publishing House)
3. Practical Biochemistry - D.T. Plummer (TATA McGraw-Hill)
4. Practical Biochemistry - R.C. Gupta & S. Bhargava
5. Experimental Physiology and Biochemistry - P.V. Chadha



KRISHNA UNIVERSITY, MACHILIPATNAM –521003

DEPARTMENT OF BIOCHEMISTRY

M.Sc Biochemistry, I-SEMESTER

Course Name	Biochemistry Laboratory - 2	L	T	P	C	IM	EM	TM
Course code	22BICL102	0	0	6	3	30	70	100

L-Lecture, T-Tutorial, P-Practical, C-Credits, IM-Internal Marks, EM-External Marks, TM-Total Marks

### List of experiments

1. Measurement of pH of a biological fluid using pH meter.
2. Isolation of Mitochondria from Rat liver by density gradient centrifugation (Demonstration).
3. Isolation and spectrophotometric characterization of plant pigments.
4. Separation of amino acids by Paper Electrophoresis (Demonstration).
5. Absorption spectra of phenol red, amino acids and nucleic acid.
6. Verification of Beer's law and determination of molar extinction coefficient using p-nitro phenol.
7. SDS-Polyacrylamide gel electrophoresis of proteins (Demonstration).
8. Qualitative determination of nucleic acids by agarose gel electrophoresis (Demonstration).
9. SDS-Polyacrylamide gel electrophoresis of proteins (Demonstration).
10. Assay of invertase from immobilized yeast cells.
11. Assay of enzyme activity and specific activity of acid / alkaline Phosphatase
12. Determination of amylase in given sample

### Books recommended:

1. Practical Biochemistry - K. Wilson & J. Walker (Cambridge Univ.Press)
2. Laboratory Manual in Biochemistry - J. Jayaraman (Narosa PublishingHouse)
3. Practical Biochemistry - D.T. Plummer (TATA McGraw-Hill)
4. Practical Biochemistry - R.C.Gupta & S.Bhargava
5. Experimental Physiology and Biochemistry -P.V.Chadha
6. Bisswanger, H. (2011) Practical Enzymology. John Wiley and Sons, New Jersey.



**KRISHNA UNIVERSITY::MACHILIPATNAM**

**COURSE STRUCTURE FOR M.Sc. BIOCHEMISTRY**

**UNDER CHOICE BASED CREDIT SYSTEM (CBCS) & OUTCOME BASED EDUCATION (OBE)**

**W.E.F 2022-23 (R22 Regulations)**

**II SEMESTER**

Course Code	Course Name	Teaching Hours/ week			CORE / IDC/DSE/ SEC/OEC/MO OCS	Internal Marks	External Marks	No. of Credits
		Lecture	Practical	Tutorial				
22BIC201	Bioinstrumentation & Bioanalytical Techniques	4	0	0	Core	30	70	4
22BIC202	Enzymology	4	0	0	Core	30	70	4
22BIC203	Intermediary Metabolism	4	0	0	Core	30	70	4
22BIC204 COMPULSORY	Research Methodology & IPR	3	1	0	SEC	30	70	3
<b>DOMAIN SPECIFIC ELECTIVE COURSES (CHOOSE ANY ONE)</b>								
22BICDSE201	Molecular Biology	4	0	0	DSE	30	70	4
22BICDSE202	Bioprocess Technology	4	0	0	DSE	30	70	4
22BICDSE203	Thermodynamics & Bioenergetics	4	0	0	DSE	30	70	4
<b>LAB PRACTICALS</b>								
22BICL201	Biochemistry Laboratory - III	0	6	0	Core	30	70	3
22BICL202	Biochemistry Laboratory - IV	0	6	0	Core	30	70	3
<b>TOTAL FOR SECOND SEMESTER</b>						<b>210</b>	<b>490</b>	<b>25</b>

At the end of 2<sup>nd</sup> semester, every student must undergo summer Internship/ Apprenticeship/Project work/Industrial training/research-based Project work for Six weeks and must prepare a report concerned as per approved project guidelines and submit the same to the University 14 days before the commencement of third semester end examinations.



KRISHNA UNIVERSITY, MACHILIPATNAM –521003

DEPARTMENT OF BIOCHEMISTRY

M.Sc Biochemistry, II-SEMESTER

Course Name	Bio-Chemical and Biophysical Techniques	L	T	P	C	IM	EM	TM
Course code	22BIC201	0	4	0	4	30	70	100

L-Lecture, T-Tutorial, P-Practical, C-Credits, IM-Internal Marks, EM-External Marks, TM-Total Marks

**Course Objective:**

Students will learn concepts and working of different analytical techniques and their applications.

To expose the students to various separation techniques.

To explain electrochemical principles in separation of compounds.

Students will understand the basic concepts and principles of biochemical separation and characterization techniques and their applications in different industries.

**Course Outline:**

**Unit - I:**

Biological relevance of pH, measurement of pH, ion selective electrodes, and oxygen electrode. Donnan membrane equilibrium

Cell fractionation & Centrifugation techniques: Cell lysis, homogenization, extraction, salting in and salting out. Dialysis and ultrafiltration-Artificial membranes, semipermeable membranes, Donnan membrane equilibrium and biological significance of osmosis. Centrifugation: Principles of centrifugation. Differential and density gradient centrifugation, construction of preparative and analytical ultracentrifuge

**Unit - II:**

Microscopy: Light, Electron (scanning and transmission), Phase contrast, Fluorescence microscopy & specific staining of cells and cell organelles.

Radioisotope techniques: Radioactivity, stable and radioactive isotopes. Methods of detection of isotopes. GM counters, liquid scintillation counters and autoradiography.

**Unit - III:**

Spectroscopy techniques: Concepts of spectroscopy, Laws of photometry, Beer-Lambert's law, Principles and applications of colorimetry, Visible, UV, IR, Fluorescence, NMR, Mass spectroscopy in structure determination of organic and biomolecules..

**Unit - IV:**

Electrophoretic techniques: Principles of electrophoretic separation, Continuous, zonal and capillary electrophoresis, different types of electrophoresis including paper, cellulose and gel (Polyacrylamide and agarose), capillary, pulse field gel electrophoresis and isoelectric

focusing

#### Unit -V:

Chromatographic techniques: Principles of partition chromatography, Paper, Thin layer, Ion-exchange, Adsorption, Reverse phase, Gel Filtration & Affinity chromatography, Gas liquid chromatography, HPLC (High performance liquid chromatography) and FPLC (Fast protein liquid chromatography)

#### Books Recommended:

1. Upadhyay, Upadhyay and Nath(1997). Biophysical Chemistry Principles and Techniques. Himalaya Publ.
2. Sambrook. Molecular Cloning(2001) . Cold Spring Harbor Laboratory.
3. Friefelder and Friefelder(1994). Physical Biochemistry – Applications to Biochemistry and Molecular Biology. WH Freeman & Co
4. Wilson and Walker (2000). A biologists guide to principles and techniques of practical biochemistry. 5th ed. Cambridge University Press 2000.
5. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan. Springer 2011.

#### Expected Course Outcomes:

After completing this course, the student will

- Obtain basic knowledge about the working principle, instrumentation and applications of Chromatography, electrophoresis and centrifugation techniques. . [K1,K2,K3,K4,K5]
- Analyse the microscopic and radioisotope techniques for their research work. . [K1,K2,K3,K4,K5]
- Explore to understand the various spectroscopic techniques for studying the molecular structure. [K1,K2,K3,K4,K5]
- Describe the principle, methodology and applications of NMR and mass spectroscopy.

\*\*\*K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create



KRISHNA UNIVERSITY, MACHILIPATNAM –521003

DEPARTMENT OF BIOCHEMISTRY

M.Sc Biochemistry, II-SEMESTER

Course Name	Enzymology	L	T	P	C	IM	EM	TM
Course code	22BIC202	0	4	0	4	30	70	100

L-Lecture, T-Tutorial, P-Practical, C-Credits, IM-Internal Marks, EM-External Marks, TM-Total Marks

**Course Objective:**

The objective of the course is to familiarize students with the structure, function and mechanisms of enzyme action, understanding kinetics of enzyme catalyzed reactions, convergent and divergent evolution of enzymes and multienzyme systems.

The course is also targeted to develop the understanding of the concepts of enzyme regulation and allosteric enzyme.

**Course Outline:**

**UNIT - I:**

Introduction: Introduction to Enzymes: Nomenclature, Classification and Characteristics of enzymes, Enzyme specificity, Cofactors, Co-enzyme and Prosthetic group, activators, inhibitors, active site, metalloenzymes, isozymes, monomeric enzymes, oligomeric enzymes and multienzyme complexes, Units of enzyme activity (definition of IU, Katal), specific activity of enzyme, measurement of enzyme activity, enzyme turnover.

Mechanism of Enzyme Action: Nature of active site, identification of functional groups at active site, enzyme substrate complex, Factors responsible for catalytic efficiency of enzymes

**UNIT - II:**

Enzyme Kinetics & Inhibition: Michaelis-Menten equation. Derivation of Michaelis-Menten equation and determination of  $K_m$  and  $V_{max}$  values, Substrate inhibition and activation, Effect of pH and temperature on rate of enzyme catalyzed reactions, Allosteric enzymes: Study of ATCase- as typical allosteric enzyme. The MWC and KNF models

Enzyme inhibition: reversible and irreversible inhibition, Kinetics of competitive, uncompetitive and non-competitive inhibition, mixed, substrate and allosteric inhibition.

**UNIT - III:**

Coenzymes, Monomeric and oligomeric enzymes: The mechanistic role of the following coenzymes in enzyme catalyzed reactions nicotinamide nucleotides, flavin nucleotides, pyridoxal phosphate, coenzyme A, thiamine pyrophosphate and biotin, Folate coenzymes

Monomeric and oligomeric enzymes: Monomeric enzymes-the serine proteases, zymogen activation. Sulphhydryl enzymes-papain. Oligomeric enzymes-isoenzymes (LDH) and multi-enzyme complexes- (Pyruvate dehydrogenase complex).

**UNIT - IV:**

Applications of Enzymes : Extraction and purification of enzymes, Enzymes as analytical reagents, Immobilized enzymes, Biotechnological applications of enzymes, Application of enzymes in medicine and industry.

#### UNIT -V:

Clinical Enzymology: Clinical enzymology - Enzymes as thrombolytic agents, anti-inflammatory agents, digestive aids. Therapeutic use of asparaginase, streptokinase. Enzymes and isoenzymes in diagnosis, Principles of diagnostic enzymology, clinical significance of alkaline and acid phosphatase, SGOT, SGPT, LDH, CPK, aspartate aminotransferase, alanine aminotransferase, creatine kinase.

#### Books Recommended:

1. Palmer T (2001) Enzymes: Biochemistry, Biotechnology and Clinical Chemistry, Horwood Publishing, Chichester, UK
2. Price NC and Stevens L (1999) Fundamentals of Enzymology, 3rd Edition, Oxford University Press Inc., New York
3. Berg JM, Tymoczko, JL and Stryer L (2002) Biochemistry, 5th Edition, WH Freeman & Co., New York
4. Dixon M and Webb EC (1979) Enzymes, 3rd Edition, Academic Press, New York
5. Seigal IH (1975) Enzyme Kinetics, Wiley Interscience, USA
5. An Introduction to Enzyme and Coenzyme Chemistry; Timothy B. Bugg, (1997) Jones and Bartlett publishers.
6. Lehninger Principles of Biochemistry; D.L. Nelson and M.M. Cox, 6th Edn. MacMillan Publications (2012).

#### Expected Course Outcomes:

After completion of the course the student shall be able to understand:

1. Uni-substrate enzyme kinetics and factors affecting enzyme activity, rate of enzyme catalyzed reactions, mapping of active site, affinity labeling and chemical modification methods. . [K1,K2,K3,K4]
2. Kinetics of multi-substrate reactions, derivation of the rate of expression of ping pong, and random bi bi reaction mechanism. . [K1,K2,K3]
3. Mechanism of action of serine proteases- chymotrypsin and triose phosphate isomerase, and convergent and divergent evolution of enzymes. . [K1,K2,K3,K4,K5]
4. Enzyme regulation, control of enzyme activity, and enzyme turn over number. . [K1,K2,K3]

\*\*\*K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create





KRISHNA UNIVERSITY, MACHILIPATNAM –521003

DEPARTMENT OF BIOCHEMISTRY

M.Sc Biochemistry, II-SEMESTER

Course Name	Intermediary Metabolism	L	T	P	C	IM	EM	TM
Course code	22BIC203	0	4	0	4	30	70	100

L-Lecture, T-Tutorial, P-Practical, C-Credits, IM-Internal Marks, EM-External Marks, TM-Total Marks

### Course Objective:

- To learn the metabolism and integration of biomolecules that takes place in the human system.. Integrate the various aspects of metabolism & their regulatory pathways.
- Students can understand the fundamental energetic of biochemical processes .
- To elaborate the relation between biochemical defects and metabolic disorders.
- To follow the organization of signaling pathways.

### Course Outline:

#### UNIT – I:

Introduction to Metabolism: Types of Metabolic Pathways, Experimental approaches to study metabolism, Basic principles/mechanisms of metabolic regulation. Basic concepts and design of metabolism. Some activated carriers in metabolism. Basic principles of bioenergetics: chemical basis of large free energy of hydrolysis of some energetic compounds; coupled reactions; group transfer; biological energy transducers. Types of biological oxidation-reduction reactions.

#### UNIT – II:

Carbohydrate Metabolism: Reactions of glycolysis, regulation of glycolysis, fermentation, feeder pathway (fructose, galactose and mannose metabolism), TCA cycle and its regulation. HMP shunt. Uronic acid pathway. Metabolism of glycogen and its regulation. Gluconeogenesis. Lactose synthesis, Glyoxylate pathway. Disorders of carbohydrate metabolism.

#### UNIT – III:

Protein & Amino Acid Metabolism: Protein turnover: chemical signals for turnover (Ubiquitin, PEST sequence). General metabolic reactions of amino acids: Transamination, deamination, oxidative and non-oxidative deamination, amino acid decarboxylation. Urea cycle and its regulation Nitrogen cycle Biological nitrogen fixation nitrogenase system. Synthesis of glutamine.

Amino Acid Metabolism - Absorption of amino acids via  $\gamma$ - glutamyl cycle. Metabolic breakdown of individual aminoacids. Biosynthesis of essential amino acids. Genetic disorders of amino acid metabolism

#### UNIT – IV:

Lipid Metabolism: Oxidation of unsaturated fatty acids. Oxidation of odd chain fatty acids. Ketogenesis. Biosynthesis of fatty acids. Regulations of lipid metabolism. Metabolism of triglycerides, phospholipids and sphingolipids. Biosynthesis of cholesterol and its regulation. Arachidonate metabolism: Biosynthesis of prostaglandins. Thromboxanes and leukotrienes (Eicosanoids). Disorders of lipid metabolism.

#### UNIT-V:

Nucleic Acid Metabolism: Nucleic Acid Metabolism: Biosynthesis, Degradation and regulation of purine and pyrimidine nucleotides. Inhibitors of nucleotide biosynthesis. Biosynthesis of deoxy ribonucleotides regulation of ribonucleotide reductase. Salvage pathway. Disorders of purine and pyrimidine nucleotide metabolism.

#### Books Recommended:

1. Biochemistry – L. Stryer.
2. Principles of Biochemistry – R. Horton et al.
3. Lehninger's Principles of Biochemistry - D. L. Nelson and M. M. Cox.
4. Harpers Biochemistry- R. K. Murray et al.
5. Principles of Biochemistry- G. L. Zubay. 6. Outlines of biochemistry- Lippincott.

#### Expected Course Outcomes:

After completion of the course the student shall be able to understand:

- Major pathways involved in carbohydrate metabolism and the role of these pathways in maintaining blood glucose homeostasis. . [K1,K2,K3]
- The pathways involved in lipid, amino acid and nucleic acid metabolism and illustrate the interplay between catabolism and anabolism. . [K1,K2,K3]
- The various types of inborn errors of metabolism and the strategies that could be employed to cope up with such metabolic defects. [K1,K2,K3]

\*\*\*K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create



KRISHNA UNIVERSITY, MACHILIPATNAM –521003

DEPARTMENT OF BIOCHEMISTRY

M.Sc Biochemistry, II-SEMESTER

Course Name	RESEARCH METHODOLOGY & INTELLECTUAL PROPERTY RIGHTS (IPR)	L	T	P	C	IM	EM	TM
Course Code	22 BIC 204	3	0	1	3	30	70	100

L-Lecture, T-Tutorial, P-Practical, C-Credits, IM-Internal Marks, EM-External Marks, TM-Total Marks

#### ❖ Course Description:

Research Methodology & IPR (PHYC204) course is aimed to develop research bent of mind (spirit of inquiry) and impart research skills to the all Post graduate students. It also encompasses the series of research methodology contents: from problem formulation, to design, to data collection, analysis, reporting and dissemination. This course also covers intellectual property rights (IPR), and intended to equip students with conceptual understandings of current scenario

of IPR, and the practical issues encountered in filing patents, trademarks and copyrights.

❖ Course Learning Objectives:

The objective of research is to find answers to the questions by applying scientific procedures. In other words, the main aim of research is to find out the truth which is hidden and has not yet been discovered

Specific objectives include:

- ✓ To understand some basic concepts of research and its methodologies
- ✓ To develop an understanding of the basic framework of research process.
- ✓ To develop an understanding of various research designs and techniques.
- ✓ To identify various sources of information for literature review and data collection.
- ✓ Ability to write a research Proposal, report and thesis
- ✓ To demonstrate knowledge and understanding of IPR Filing and Rights

❖ Course Learning Outcomes:

At the end of this course the students should be able to:

- Understand some basic concepts of research and its methodologies
- Identify appropriate research topics
- Select and define appropriate research problem and parameters
- Demonstrate the ability to choose methods appropriate to research aims and objectives
- Have adequate knowledge on measurement & scaling techniques
- Have basic awareness of data analysis-and hypothesis testing procedures
- Prepare a project proposal (to undertake a project)
- Write a research report and thesis
- File Patents, Trademarks and Copy Rights

❖ Course Content:

UNIT- I: Foundations of Research & Research Design

Meaning of Research – Definitions of Research – Motivation in Research – General Characteristics of Research – Criteria of Good Research – Types of Research – Research Process – Research Methods vs. Methodology – Defining and Formulating the Research Problem – Review of Literature – Approaches to Critical Literature Review – Importance of Literature Review in Identifying Research Gaps and Defining a Problem – Development of Working Hypothesis.

UNIT- II: Research Design, Sampling Concepts, and Data Collection Methods

Meaning, Significance and Characteristics of Good Research Design–Types of Research Design: Exploratory, Conclusive Research and Experimental – Sampling Theory: Types of Sampling and Errors in Sampling – Data Collection: Types of Data – Data Collection Methods and Techniques for Primary and Secondary Data.

UNIT-III: Measurement & Scaling Techniques, Hypothesis Formulation and Testing, Overview of Data Analysis and Report Writing

Basic measurement scales –Reliability & Validity – Definition and Types of Hypothesis– Hypothesis Formulation and Testing Procedure – Overview of Data Analysis: Methods, Process and Types– Report Writing: Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report Precautions for Writing Research Reports – How to Write a Research Proposal– Research Ethics, Conflict of Interest and Plagiarism.

UNIT- IV: Intellectual Property Rights (IPR)

Definition and Nature and Features of Intellectual Property Rights (IPR) –Types of Intellectual

Property Rights – Procedure for Grants of Patents –Rights of a Patent – Scope of a Patent Rights-Licensing and Transfer of Technology–Why protection of intellectual property is important? Enforcement of IPR – Infringement of IPR

#### UNIT -V: Indian and International Scenario and New Developments in IPR

IPR Developments in India for the past Five Years – Development of IPR Laws in India – International Cooperation on IPR – New Developments in IPR – Administration of Patent System – International Patent protection – Case Studies in Indian and Global Contexts.

#### PRACTICAL COMPONENTS:

1. Students should identify different research problems with examples and describe the characteristics of researchable problems in their academic area/society/community/organization concerned.
  2. Students are to form in groups (a group consists of 4-6 students) and conduct critical literature survey with regard to the identified research problems and prepare a brief literature review coupled with research gaps and working hypothesis.
  3. Students are required to identify and develop good research design to address the defined research problems.
  4. Students are expected to write the research design on Exploratory and Descriptive Research.
  5. Students are required to develop practical experience in writing a research proposal by conducting a thorough critical review of any three research proposals (examples).
  6. Students are expected to develop templates for technical report writing.
  7. Students should conduct a team based mini research project, which is a unified and practical case on a topic of their choice, with approximately 4-6 students per group.
  8. Students are expected to identify types of plagiarism in academic research, and how to avoid plagiarism in research.
  9. Students are asked to identify and submit a brief report on Indian patents of international repute.
  10. Students are asked to write on Patent registration procedure, and visit Official website of Intellectual Property India <https://ipindia.gov.in> to know how to get IPR in India.
  11. Students are asked to identify and summarize remedies available against the infringement of intellectual property rights in Indian and global contexts.
- Students are asked to submit any five examples of ethical issues in copyright and patents.

#### Text and Reference Books:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002, An introduction to Research Methodology, RBSA Publishers.
2. Cohen, L. Lawrence, M., & Morrison, K. (2005), Research Methods in Education (5th edition). Oxford: Oxford University Press.
3. Kothari, C.R., 1990, Research Methodology: Methods and Techniques, New Age International.
4. Dornyei, Z. (2007). Research Methods in Applied Linguistics. Oxford: Oxford University Press.
5. Anthony, M., Graziano, A.M. and Raulin, M.L., 2009, Research Methods: A Process of Inquiry, Ally and Bacon.
6. Fink, A., 2009, Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications.
7. Day, R.A., 1992, How to Write and Publish a Scientific Paper, Cambridge University Press.
8. Wadehra, B.L. 2000, Law relating to patents, trade marks, copyright designs and geographical indications. Universal Law Publishing.
9. Coley, S.M. and Scheinberg, C. A., 1990, Proposal Writing, Sage Publications.
10. Carlos, C.M., 2000. Intellectual property rights, the WTO and developing countries: the TRIPS agreement and policy options, Zed Books, New York.
11. Leedy, P.D. and Ormrod, J.E., 2004, Practical Research: Planning and Design, Prentice Hall.
12. Satarkar, S.V., 2000. Intellectual property rights and Copy right. Ess Ess Publications.

#### Important Websites:

- [www.ipindia.nic.in](http://www.ipindia.nic.in) - Intellectual Property Office, India

- [www.patentoffice.nic.in](http://www.patentoffice.nic.in) – Patent office, India
- <http://copyright.gov.in/> - Copyright Office, India
- [ipr.icegate.gov.in](http://ipr.icegate.gov.in) – Automated Recordation & Targeting for IPR Protection
- <http://www.icegate.gov.in>- E- Commerce portal of Central Board of Excise and Customs
- [www.ipab.tn.nic.in](http://www.ipab.tn.nic.in) - Intellectual Property Appellate Board, India
- [www.mit.gov.in](http://www.mit.gov.in) – Department of Information Technology, India
- <http://www.mit.gov.in/content/office-semiconductorintegrated-circuits-layout-designregistry>
- Semiconductor Integrated Circuits Layout-Design Registry (SICLDR)
- [www.plantauthority.gov.in](http://www.plantauthority.gov.in) – Plant Varieties and Farmers' Rights Authority, India
- <http://nbaindia.org/> - National Biodiversity Authority
- [www.nipo.in](http://www.nipo.in) – The Indian IPR Foundation
- [www.wipo.int](http://www.wipo.int) – World Intellectual Property Organisation
- <http://www.wto.org> – World Trade Organisation



**KRISHNA UNIVERSITY, MACHILIPATNAM –521003**

**DEPARTMENT OF BIOCHEMISTRY**

**M.Sc Biochemistry, II-SEMESTER**

Course Name	Molecular Biology	L	T	P	C	IM	EM	TM
Course code	22BICDSE201	0	4	0	4	30	70	100

L-Lecture, T-Tutorial, P-Practical, C-Credits, IM-Internal Marks, EM-External Marks, TM-Total Marks

### Course Objective:

To inculcate an understanding of scientific processes of molecular biology.

- To gain understanding of finer details of the important phenomenon in molecular biology.
- To prepare the students to take up higher studies and research in the areas related to molecular biology.

### Course Outline:

#### UNIT 1

DNA replication: Mechanism of replication, the replicons, origin, primosome and replisomes, properties of prokaryotic and eukaryotic DNA polymerases, synthesis of leading and lagging strands, difference between prokaryotic and eukaryotic replication, inhibitors of replication, telomeres and telomerase, homologous and site-specific recombination.

#### UNIT II

RNA synthesis and processing: transcription factors and machinery, formation of initiation complex, transcription activators, repressors and insulators; RNA polymerases, capping, elongation, and termination, Post-transcriptional modifications of mRNA and processing of pre-tRNA & pre-rRNA, Turnover of RNA, Transport of processed mRNA, Reverse transcription.

### UNIT III

Protein synthesis and processing: Ribosomes, structure, functional domain and subunit assembly, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code [definition, deciphering of the genetic code, codon dictionary, salient features of genetic code]. aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, Posttranslational modification of proteins, protein targeting and degradation,

### UNIT IV

Regulation of Transcription and Translation: Positive and negative control. Repressors, activators and insulators in regulating the expression of phages, viruses, prokaryotic and eukaryotic genes. DNA binding motifs in pro- & eukaryotes, helix-turn-helix, zinc fingers, leucine zippers/b zip, helix-loop- helix motifs. Non-coding RNAs (miRNA, snRNA, pRNA).

### UNIT V

Regulation of gene expression: Constitutive, Inducible and Repressible gene expression, Positive and Negative control of gene expression, Lac, Tryptophan, arabinose operons. Role of chromatin in regulating gene expression. Epigenetics and its importance in regulation of gene expression

### Books Recommended:

1. Biochemistry (III/IV/V/VI edition, 2008) L. Stryer, WH Freeman and Co.
2. Molecular biology of the gene (VII edition, 2014) J D Watson, Person education Inc.
3. Molecular Cell Biology (8th edition.2016) by Harvey Lodish et al.
4. Molecular biology of the cell 6th edition (2014) B. Alberts, Garland Pub. In., NY
5. Genes X (2010), B. Lewin, John Wiley and sons, NY.
6. Molecular Biology David Freifelder Naro 1995.Publishing House, New Delhi 6. Molecular Biology Weaver R F, 1999..McGraw Hill Inc. NY th

### Expected Course Outcomes:

acquire better understanding and comprehensive knowledge regarding most of the essential aspects of Molecular Biology subject which in turn will provide a fantastic opportunity to develop professional skill related to the field of molecular biology.[K1,K2]

\*\*\*K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create



KRISHNA UNIVERSITY, MACHILIPATNAM –521003

DEPARTMENT OF BIOCHEMISTRY

M.Sc Biochemistry, II-SEMESTER

Course Name	Bioprocess Technology	L	T	P	C	IM	EM	TM
Course code	22BICDSE202	0	4	0	4	30	70	100

L-Lecture, T-Tutorial, P-Practical, C-Credits, IM-Internal Marks, EM-External Marks, TM-Total Marks

### Course Objective:

It covers important topics in the development, production, recovery, and analysis of products produced by biotechnology. The course traces the path of a biological product from the cell through the production facility, the final processing, and formulation. It discusses the growth characteristics of the organisms used to produce biological compounds, the techniques used in product recovery and purification analysis.

### Course outline:

#### Unit I:

Introduction to The fundamental concept of Fermentation and bioprocess technology. Range of bioprocess technology and its chronological development. Types of microbial culture and its growth kinetics– Batch, Fedbatch and Continuous culture.

#### Unit II:

Bioreactors-design, types and operation. Bioreactors, bioreactor design, criteria, operation and types of bioreactors. Agitation and aeration in the bioreactor, impeller and sparger design. Concept of scale up, scale up challenges.. Bioprocess monitoring and control, automated control vs manual control of bioprocesses.

Unit III: Criteria for medium design, carbon/nitrogen sources, nutrients Sterilization of media Bioprocess measurement and control system with special reference to computer aided process control Influence of various bioprocess parameters viz. pH, temperature, medium components on product synthesis.

Unit IV: Downstream processing Downstream processing: definition, cost involved in downstream processing. Typical steps involved in Downstream processing. Criteria for downstream processing, Target application of product vs cost, separation of cells and broth. Typical unit operation for downstream processing filtration, centrifugation, chromatography, solvent extraction, HPLC. Methods for cell breakage for harvesting intercellular products.

#### Unit V:

Bioprocess based products and application. Commercial production of various bioprocess based products (Bioethanol, butanol, citric acid, acetic acid. Antibiotics-penicillin, streptomycin, tetracycline. Single cell protein; amino acids: glutamic acid, lysine Types and nature of wastes generated from bioprocesses .

### Books Recommended:

1. Principles of Fermentation Technology, P.F.Stanbury, A Whitaker and S.J.Hall, , 2008.

Elsevier

2. 2. Bioprocess Technology, P.T.Kalichelvan and I Arul Pandi, 2009,MJP Publishers, Chennai.
3. 3. Bioprocess Engineering,M.Shuler&F.Kargi (2002). Prentice Hall (I) Ltd., N.Delhi.
4. Bioprocess Technology- Kinetics and reactors ,Antan Moser and Philip Manor,.1998, Springer
5. Fermentation Microbiology and Biotechnology ,E.M.T. Mansi, C.F.A . Bryce. A.L..Dmain, A.R.Alliman. ,2009, Taylor and Francis. New York
6. Industrial Microbiology, Cassida L.E. 1968.John Wiley and Sons Publishers.
7. Biotechnology: fundamentals and Applications - Purohith and Mathur, Agrobotanical Publishers, India
8. Biotechnology: The biological Principles. Trevan et al., Tata McGraw Hill Edn.
9. Biotechnology - An introduction by Susan R Barnum, Thomsu

### Expected Course Outcomes:

At the end of the course the students will,

- Learn and understand cell growth, goals of fermentation and relate it to a real-life example [K1,K2].
- Different types of bioreactor, auxiliary equipment, working principle and industrial applications are understood[K1,K2,K3,K4]
- Students understand how parameters such as pH, temperature, aeration, and agitation that affects the fermentation[K1,K2]
- Students learn the industrial production of certain metabolites and their recovery[K1,K2,K3]

. \*\*\*K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create





KRISHNA UNIVERSITY, MACHILIPATNAM –521003

DEPARTMENT OF BIOCHEMISTRY

M.Sc Biochemistry, II-SEMESTER

Course Name	Thermodynamics & Bioenergetics	L	T	P	C	IM	EM	TM
Course code	22BICDSE203	0	4	0	4	30	70	100

L-Lecture, T-Tutorial, P-Practical, C-Credits, IM-Internal Marks, EM-External Marks, TM-Total Marks

#### UNIT-I:

Thermodynamics Introduction, systems: (isolated, closed, open) and surrounding. First and second law of thermodynamics, internal energy, enthalpy, entropy. Concept of free energy, standard free energy change of a chemical reaction. concept of thermal equilibrium and the zeroth law of thermodynamics. High-energy compounds

#### UNIT-II

Energy transducing membrane, Oxidation and reduction reaction, Ubiquinone, Iron-sulphur center, co-enzyme and proteins as universal electron carrier, electron transport system in mitochondria, structure of different electron carrier, chemiosmotic theory of Peter Mitchell, oxidative phosphorylation, Proton Motive force, P/O ratio, uncouplers, thermodynamics of electron transport system in mitochondria

#### UNIT-III

Thermodynamics of protein folding, Biogenetics of amyloidogenesis, Stability of extreme proteins (thermophile and cryophile), stability of intrinsically disordered proteins, thermodynamic based regulation of metabolic pathways, bacterial photosynthesis, thermodynamic consideration of light harvesting complex in plants and ATP synthesis in thylakoid membrane.

#### UNIT-IV

Thermodynamics of bonding, types of bonding, hydrogen bonding, van der Waals interaction, electrostatic interaction and hydrophobic interaction, role of non-covalent interaction in the stability of biomolecules, thermodynamics of antigen-antibody interaction, thermodynamics of receptor-ligand interaction.

#### UNIT-V

Methods used to calculate thermodynamic parameters, Principle and application of Differential Scanning Calorimetry (DSC), Isothermal Titration Calorimetry (ITC) and Surface Plasmon Resonance (SPR), Spectroscopic methods used for calculating of enthalpy, entropy and Gibbs free energy.

#### Books recommended

1. Voet D., Voet J.G, Biochemistry 4th Edition., John Wiley and Sons, 2011.
2. Nelson, D. C. and Cox, M.M., Lehninger Principles of Biochemistry, 5th Edition, W. H. Freeman, 2010.
3. Berg J.M., Tymoczko J.L. and Stryer L., Biochemistry. 7th edition, W.H. Freeman and Co. New York, 2011.

## Course Outcomes:

At the end of the course the students will,

- the sources of energy supply of the processes running in the living organisms and molecular mechanisms of the energy transformation in the cells[K1,K2].
- the thermodynamics of the biological (living) systems: exergonic and endergonic reactions, Gibbs (free) energy, spontaneous and non-spontaneous reactions, free energy changes of coupled reactions[K1,K2].
- the basic methods for quantitative analysis of parameters characterizing the energetical status of the cell. [K1,K2].

\*\*\*K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 – Create



KRISHNA UNIVERSITY, MACHILIPATNAM –521003

DEPARTMENT OF BIOCHEMISTRY

M.Sc Biochemistry, II-SEMESTER

Course Name	Biochemistry Laboratory - III	L	T	P	C	IM	EM	TM
Course code	22BICL201	0	0	6	3	30	70	100

L-Lecture, T-Tutorial, P-Practical, C-Credits, IM-Internal Marks, EM-External Marks, TM-Total Marks

1. Isolation of RNA from yeast/ E.coli
2. Isolation of genomic DNA from bacteria
3. Isolation of genomic DNA from plant cell/animal cell
4. Gel electrophoresis of isolated DNA
5. Estimation of DNA by diphenylamine reaction
6. Estimation of RNA by orcinol method
7. Isolation of plasmid DNA from E. coli by Alkaline SDS method
8. Transformation by CaCl<sub>2</sub> and PEG method
9. Restriction digestion and Gel electrophoresis
10. Determination of melting temperature (T<sub>m</sub>) and estimation of GC content.
11. Isolation of plasmids from *E.coli* and separation of CCC, Open circular and linear forms of plasmids

### Books recommended:

- Practical Biochemistry - K. Wilson & J. Walker (Cambridge Univ.Press)
- Laboratory Manual in Biochemistry - J. Jayaraman (Narosa PublishingHouse)
- Practical Biochemistry - D.T. Plummer (TATA McGraw-Hill)



KRISHNA UNIVERSITY, MACHILIPATNAM –521003

DEPARTMENT OF BIOCHEMISTRY

M.Sc Biochemistry, II-SEMESTER

Course Name	Biochemistry Laboratory - IV	L	T	P	C	IM	EM	TM
Course code	22BICL202	0	0	6	3	30	70	100

L-Lecture, T-Tutorial, P-Practical, C-Credits, IM-Internal Marks, EM-External Marks, TM-Total Marks

1. Isolation of Mitochondria from Rat liver by density gradient centrifugation (Demonstration).
2. Isolation and spectrophotometric characterization of plant pigments.
3. Separation of amino acids by Paper Electrophoresis (Demonstration).
4. Absorption spectra of phenol red, amino acids and nucleic acid.
5. Verification of Beer's law and determination of molar extinction coefficient using p-nitro phenol.
6. SDS-Polyacrylamide gel electrophoresis of proteins (Demonstration).
7. Qualitative determination of nucleic acids by agarose gel electrophoresis (Demonstration).
8. 8.SDS-Polyacrylamide gel electrophoresis of proteins (Demonstration)
9. Separation of lipids by thin layer chromatography.
10. HPLC-Demonstration
11. Isolation and partial purification of enzymes: amylases and cellulases.
12. Localization of enzymes – mitochondrial (SDH) and cytosolic (GSH)
13. Effect of temperature and pH on the rate of enzyme-catalyzed reaction.
14. Effect of inhibitors/activators on enzyme-catalyzed reactions.

**Books recommended:**

7. Practical Biochemistry - K. Wilson & J. Walker (Cambridge Univ.Press)
8. Laboratory Manual in Biochemistry - J. Jayaraman (Narosa PublishingHouse)
9. Practical Biochemistry - D.T. Plummer (TATA McGraw-Hill)
10. Practical Biochemistry - R.C.Gupta & S.Bhargava