Choice Based Credit System of
B.Sc. (Biochemistry)
(6 Semester Degree Course)

Mizoram University, Aizawl
October - 2021

CBCS Course Structure of B.Sc (Biochemistry)
(6 Semester Degree Course)

Sem	Course No.	Name of Paper	Credit	Page No.
		Course Structure		2-6
1st	BCHEM/I/EC/01	BCHEM -I: Introduction to Biochemistry	**4**	7
	BCHEM /I/EC/02	Practical – I	**2**	8
2nd	BCHEM /II/EC/03	BCHEM - II: Biomolecules	**4**	9
	BCHEM /II/EC/04	Practical – II	**2**	10
3rd	BCHEM /III/EC/05	BCHEM -III: Enzymology & Bioenergetics	**4**	11
	BCHEM III/EC/06	Practical – III	**2**	12
4th	BCHEM /IV/EC/07	BCHEM - IV: Intermediary metabolism	**4**	13
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5th	BCHEM /V/CC/09	BCHEM -V: Biochemical techniques	**4**	15
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	BCHEM /V/CC/11	BCHEM -VI: Microbiology & Immunology	**4**	17
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	BCHEM /V/CC/13	BCHEM -VII: Physiological chemistry	**4**	19
	BCHEM /V/CC/14	Practical – VII	**2**	20
	BCHEM /V/CC/15 (a) BCHEM /V/CC/15 (b)	**Optional I** (*any one*) BCHEM -VIII: Cell & membrane biology BCHEM -IX: Genetics	**4**	21-22 23
	BCHEM /V/CC/16	Project – I	**6**	24
6th	BCHEM /VI/CC/17	BCHEM -X: Clinical Biochemistry	**4**	25
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	BCHEM /VI/CC/19	BCHEM XI: Nutritional Biochemistry	**4**	27
	BCHEM /VI/CC/20	Practical - IX	**2**	28
	BCHEM /VI/CC/21	BCHEM -XII: Molecular biology	**4**	29
	BCHEM /VI/CC/22	Practical - X	**2**	30
	BCHEM /VI/CC/23 (a) BCHEM /VI/CC/23 (b)	**Optional II** (*any one*) BCHEM -XIII: Genetic engineering & Biotechnology BCHEM -XIV: Environmental Biochemistry	**4**	31-32 33
	BCHEM /VI/CC/24	Project – II/Education Tour/Field Trip	**6**	34
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Course Structure & Marks Distribution of B.Sc. (Biochemistry)

Sem	Course No.	Name of Paper	Marks Scale			Credit				Exam(hrs)	
			C/A	End Sem	Tot	L	T	P	Tot	T	P
1st	ENG/I/FC/01	English I	25	75	100	4	1	0	**5**	*3*	-
	BCHEM/I/EC/01	BCHEM -I: Introduction to Biochemistry	25	75	100	3	1	0	**4**	3	-
	BCHEM /I/EC/02	Practical – I	25	75	100	0	0	2	**2**	-	3
	Elec. Course-1	Theory	25	75	100				***4***		
		Practical	25	75	100				***2***		
	Elec. Course-2	Theory	25	75	100				***4***		
		Practical	25	75	100				***2***		
		Total	175	525	**700**				**23**		
2nd	ENG/II/FC/02	English II	25	75	100	4	1	0	**5**	*3*	-
	BCHEM /II/EC/03	BCHEM -II: Biomolecules	25	75	100	3	1	0	**4**	3	-
	BCHEM /II/EC/04	Practical – II	25	75	100	0	0	2	**2**	-	3
	Elec. Course-1	Theory	25	75	100				***4***		
		Practical	25	75	100				***2***		
	Elec. Course-2	Theory	25	75	100				***4***		
		Practical	25	75	100				***2***		
		Total	175	525	**700**				**23**		
3rd	HSCI/III/FC/03	History of Science	25	75	100	4	1	0	**5**	*3*	-
	BCHEM /III/EC/05	BCHEM -III: Enzymology & Bioenergetics	25	75	100	3	1	0	**4**	3	-
	BCHEM III/EC/06	Practical – III	25	75	100	0	0	2	**2**	-	3
	Elec. Course-1	Theory	25	75	100				***4***		
		Practical	25	75	100				***2***		
	Elec. Course-2	Theory	25	75	100				***4***		
		Practical	25	75	100				***2***		
		Total	175	525	**700**				**23**		
4th	EVS/IV/FC/04	Environmental Studies	25	75	100	4	1	0	**5**	*3*	-
	BCHEM /IV/EC/07	BCHEM -IV: Intermediary metabolism	25	75	100	3	1	0	**4**	3	-
	BCHEM /IV/EC/08	Practical – IV	25	75	100	0	0	2	**2**	-	3
	Elec. Course-1	Theory	25	75	100				***4***		
		Practical	25	75	100				***2***		
	Elec. Course-2	Theory	25	75	100				***4***		
		Practical	25	75	100				***2***		
		Total	175	525	**700**				**23**		
	BCHEM /V/CC/09	BCHEM -V: Biochemical techniques	25	75	100	3	1	0	**4**	3	-
	BCHEM	Practical – V	25	75	100	3	1	0	**4**	3	-

	/V/CC/10										
5th	BCHEM /V/CC/11	BCHEM -VI: Microbiology & Immunology	25	75	100	3	1	0	**4**	3	-
	BCHEM /V/CC/12	Practical – VI	25	75	100	0	0	2	**2**	-	3
	BCHEM /V/CC/13	BCHEM -VII: Physiological chemistry	25	75	100	0	0	2	**2**	-	3
	BCHEM /V/CC/14	Practical – VII	25	75	100	0	0	2	**2**	-	3
	BCHEM /V/CC/15 (a) BCHEM /V/CC/15 (b)	**Optional I** (*any one*) BCHEM -VIII: Cell & membrane biology BCHEM -IX: Genetics	25	75	100	3	1	0	**4**	3	-
	BCHEM /V/CC/16	Project – I	25	75	100	0	0	6	6	-	3
		Total	200	600	**800**				**28**		
6th	BCHEM /VI/CC/17	BCHEM -X: Clinical Biochemistry	25	75	100	3	1	0	**4**	3	-
	BCHEM /VI/CC/18	Practical - VIII	25	75	100	3	1	0	**4**	3	-
	BCHEM /VI/CC/19	BCHEM XI: Nutritional Biochemistry	25	75	100	3	1	0	**4**	3	-
	BCHEM /VI/CC/20	Practical - IX	25	75	100	0	0	2	**2**	-	3
	BCHEM /VI/CC/21	BCHEM -XII: Molecular biology	25	75	100	0	0	2	**2**	-	3
	BCHEM /VI/CC/22	Practical - X	25	75	100	0	0	2	**2**	-	3
	BCHEM /VI/CC/23 (a) BCHEM /VI/CC/23 (b)	**Optional II** (*any one*) BCHEM -XII: Genetic engineering & Biotechnology BCHEM -XIV: Environmental Biochemistry	25	75	100	3	1	0	**4**	3	-
	BCHEM /VI/CC/24	Project – II/Education Tour/Field Trip	25	75	100	0	0	6	**6**	-	3
		Total	200	600	**800**				**28**		
		Grand Total	**1100**	**3300**	**4400**				**148**		
			Theory Credit						**100**	**(71.4%)**	
			Practical Credit						**40**	**(28.6%)**	

Key Points:

1. In teaching all the courses of Biochemistry, S.I. units will be followed.
2. Contact hour per Lecture is 1 hour. For Theory, 1 Contact hour is 1 Credit and for

Practical, 2 Contact hours is 1 Credit.

3. Internal Tests/Assignments will be conducted as a part of Internal Assessment as per CGS Regulations (UG) of Mizoram University.

C. Core and Elective Papers

The permitted combinations of Core and Elective papers for Biochemistry are as given below:

Core	**Elective I**	**Elective II**
Biochemistry	Chemistry	Zoology /Botany
Zoology	Chemistry	Botany /**Biochemistry**
Botany	Chemistry	Zoology /**Biochemistry**
Chemistry	Mathematics/ Zoology	Physics/**Biochemistry**/Botany

D. Examination Pattern

- Internal Tests as per CGS guidelines for UG (MZU)
- In the End Semester examinations, following is the marks distribution and the pattern of setting the questions in Theory and Practical Papers.

Papers with Marks	**Internal (C1+C2) = 25 marks** **Marks distribution** As per CBCS guidelines for UG	**External (C3)-75 marks**	**Duration of Examn.**
Core & Optional (Theory) 60	**External (C3)** **A. *Objective Type Questions*** (Part A) **-35 marks** No. of MCQ to be set = **10** (**1** marks) No. of MCQ to be answered = **10** **B. *Short Answer Type*** No. of S.A. Qs. to be set= **10** (2 from each Unit with **3** marks) No. of S.A. Qs. to be answered= **5** (1 from each Unit)	**Descriptive Questions** **(Part B) – 40 marks** C. *Descriptive Questions* No. of Qs. to be set = **10** (2 from each Unit with **10** marks) No. of Qs. to be answered = **5** (1 from each Unit)	3 hours
Practical 100	**Internal (C1+C2=25 marks)** For BCHEM /I/EC/02, BCHEM	**External (75 marks)** End Semester–**50** marks,	3 hours

E. Internal and External Examination

Examination and Assessment: Each Course, shall be evaluated at the scale of 100. For all courses, irrespective of Theory and Practical, there shall be Continuous (internal) Assessment carrying 25 marks and an End-semester examination carrying 75 marks.

1) **Continuous Assessment:**

The outline for Continuous Assessment activities shall be proposed by the teacher(s) concerned before the commencement of the semester. Some suggested parameters of Continuous Assessment are Class Tests, Seminar, Quiz, Home Assignments, Project, and many other methods. However, there shall be series of tests at regular intervals for each course (paper) incorporating various parameters as given above. Final marks shall be calculated for total 25 Marks.

The scheme of awarding marks in Internal Assessment for Theory courses shall be as below:

Component	Total marks
Class Tests (Average of two Continuous Test)	12 marks
Assignment/Seminar/Project etc.	8 marks
Regularity in the class	5 marks

The scheme of awarding marks in Internal Assessment for Practical courses shall be as given below:

Evaluation in the Lab and Record	8 marks
End-semester Test	12 Marks
Regularity in the class	5 Marks

Attendance evaluation for each course shall be as given in below:

Attendance	Marks
90% and above	5
85 to 89.9%	4
80 to 84.9%	3
76 to 79.9%	2
75 to 75.9%	1

2) The End-semester Examination

For each Course (separately for Theory and Practical), End-semester examination shall be conducted for 75 marks each. Finally, the marks obtained in Internal Assessment and End-semester Examination in each course shall be pooled and the % marks obtained shall be calculated by the Examination Department.

OBJECTIVE OF THE COURSE

Biochemistry, the study of biological phenomena at cellular and molecular level, is studied to gain knowledge about the principles that govern complex biological systems. The primary objective of this course is to give students a solid foundation in biochemical processes, to develop analytical, technical and critical thinking skills and to make them scientifically literate so as to contribute to the discipline after graduation.

SYLLABI AND COURSES

The syllabus pertaining to B.Sc. (Core) Biochemistry (3 Year course & 6 Semesters) in the subject of Biochemistry has been framed as per provision of the UGC module for CHOICE BASED CREDIT SYSTEM and demand of the academic environment. The syllabus contents are duly arranged unit wise and contents are included in such a manner that due importance is given to requisite intellectual and laboratory skills according to UGC module for CHOICE BASED CREDIT SYSTEM pertaining to B.Sc. in Biochemistry.

FIRST SEMESTER
BCHEM - I: INTRODUCTION TO BIOCHEMISTRY
Course No: BCHEM/I/EC/01

Marks Scale: 100 marks **Credit: 4**
(End Sem.: 75+ Int.: 25) **(L-T-P: 3- 1- 0)**

Objective: *The course is designed to give students basic concepts of biochemistry and its nature of interdisciplinary importance. To let students understand the physical and chemical properties of molecules, and their status of occurrence in biological system.*

Course outcomes: *on completion of the course, student will be able to understand:*

- *nature of biochemistry*
- *physical and chemical properties of molecules as a linkage of biochemistry*
- *concept and properties of acid-base relationship*

Unit 1: Overview of Biochemistry

Overview of Biochemistry- Definition, scope and significance of Biochemistry. History and important discoveries in Biochemistry. An overview of elements, chemical reactions and biomolecules in living organisms. Biochemistry as molecular logic of living organisms.

Unit 2: Physical properties of molecules

Ionic product of water. Molecular structure of water, physical properties of water. Its effect on biomolecules. Effect of non-polar compounds on water. Hypo, hyper and isotonic solutions. Osmotic pressure , Effects of osmotic pressure on living cells. Donnan membrane equilibrium. Adsorption and Viscosity -Definition, and applications.

Unit 3: Ionic equilibria

Lewis concept of acids and bases. pH and pKa, buffers, Henderson Hasselbalch equation, biological buffers. Theory of acid base indicators. Choice of indicators, pH titration curves. Electrodes (Hydrogen Electrode &Calomel electrode), glass electrode.

Unit 4: Chemical bonding & Concentration units

Ionic bonding, covalent bonding, co-ordinate bonding, Van der Waal's forces, ion- dipole, dipole –dipole interactions, London forces, hydrophobic interaction, hydrogen bonding. Avogadro's number, mole, mole fraction, molarity, equivalent weight, normality, molality, percentage.

Unit 5: Elements in living organisms

Nitrogen: Fixation of atmospheric nitrogen, symbiotic and non-symbiotic. Carbon, hydrogen, Oxygen, Phosphorous, Sulphur, - Their importance in biological system. Source, entry in to biological system and toxicity of - lead, mercury, cadmium and arsenic..

References

1. Barrow, G. M (2007). Physical Chemistry Tata McGraw-Hill, India.
2. Kotz, J. C., Treichel, P. M. and Townsend, J. R (2009) General Chemistry Cengage Le arning India Pvt. Ltd.: New Delhi.

3. Douglas, McDaniel and Alexander (1994). Concepts and Models in Inorganic Chemistry, John Wiley, 3rd edition
4. James E. Huheey, Ellen Keiter and Richard Keiter (2013). Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Public, 4th Edition.
5. Pattabhi. V. and Gautham. N (2002). Biophysics. Narosa Publishing House, India. Physical Chemistry – Puri, Pathania& Sharma

FIRST SEMESTER
PRACTICAL – I
Course No: BCHEM /I/EC/02

Marks Scale: 100 marks **Credit: 2**
(End Sem.: 75+ Int.: 25) **(0- 0- 2)**

Objective: *To expose students in basic biochemistry practical laboratory to see basic tools used in practical. To acquire confidence, interest, challenge and discipline laboratory behaviour in biochemistry practical.*

Course outcome: *on completion of the course students will be able to:*

- *use simple laboratory instruments for carrying out practical.*
- *do calculations based on the experiment.*
- *understand acid-base interaction.*
- *understand the importance of following safety measures during every practical.*
- *Prepare solutions and reagents.*

One (1) experiment is to be performed within 3 hours in the End Semester examination. A minimum of 4 experiments is to be performed by the students

1) Use of analytical balance and weighting.
2) Calculation, preparation of normal, molar and percentage solutions.
3) Calibration of volumetric glassware (Burette, pipette and measuring cylinder).
4) Conductometric titration of strong acid against strong base.
5) Safety measures in laboratory.
6) Good laboratory practices.

SECOND SEMESTER
BCHEM - II: BIOMOLECULES
Course No: BCHEM /II/EC/03

Marks Scale: 100 marks **Credit: 4**
(End Sem.: 75+ Int.: 25) **(L-T-P: 3- 1- 0)**

Objective: *To familiarize the students with major biomolecules namely carbohydrates, lipids, proteins and nucleic acids which are important for the structural organization and functions of the cells. The course encompasses the overall perspective on the biomolecules their characteristic properties and organization in carrying out all the living functions which constitute the life.*

Course Outcome: *On completion of the course, students shall be able to:*

- *assess and relate the concepts of chemistry to biology.*
  identify the structures of amino acids, their chemical properties and their organization into polypeptides and proteins.
- *understand the structure and functions of fundamental mono, di and trisaccharide and polysaccharides. Relate the basic function of nucleotides, structure of different classes of lipids and their roles in biological systems*

Unit 1: Carbohydrates
Classification and biological role of carbohydrates; chemistry of mono-, di- and polysaccharides; Stereochemistry of sugars: chiral carbon, epimers, mutarotation, chair and boat forms, glycoside, glucopyranose and fructopyranose. Reducing and non- reducing sugars.

Unit 2: Proteins
Amino acids: classification, chemical structure and general properties. Proteins - classification, biological role and structural organization of protein - Primary structure, Secondary, tertiary and quaternary structure; forces stabilizing the structure of proteins. Molecular chaperones in protein folding.

Unit 3: Lipids
Lipid classifications & biological role; Fatty acids; General formula, Nomenclature and chemical properties; saturated and unsaturated fatty acids; general structure and functions of the major lipid sub-classes- triacylglycerols, phospholipids and steroids.

Unit 4: Nucleic Acids
Structure and functions of nucleotides. Forms of DNA, Watson-Crick model of DNA. Structure and functions of major species of RNA - mRNA, tRNA and rRNA; effect of acid and alkali on DNA.

Unit 5: Porphyrins and Prostaglandins
Porphyrin nucleus and classification. Important metalloporphyrin's occurring in nature-structure and their biological importance (Hb, cytochrome, chlorophyll, VitB_{12}).
Prostaglandins, structure and biochemical actions. Biological roles of thromboxane, leukotrienes and prostaglandins.

References

1. Satyanarayana, U (2013). *Biochemistry*, (4th ed.). Reed Elsevier India Pvt. Ltd & Books and Allied Pvt Lmt. India. ISBN- 978-81-312-3601-7.
2. Nelson, D.L and Cox, M.M (2008*). Lehninger's Principles of Biochemistry*, Macmillan Pub.
3. Agarwal, O.P (2008). *Fundamentals of Biochemistry*, (11th ed.). Goel Publishing House.
4. Jain, A.I (2004). *Essentials of Biochemistry*, (2nd ed.). S. Chand publications.
5. Anil, K., Sarika, G and Neha, G (2012). *Biochemical Tests – Principles and Protocols*. Vinod Vasishtha Viva Books Pvt Ltd.
6. Boyer, R.F (2012). Biochemistry *Laboratory: Modern Theory and Techniques*, (6th ed.). Boston, Mass: Prentice Hall, 2012, ISBN-13: 9780136043027.

SECOND SEMESTER
PRACTICAL –II
Course No: BCHEM /II/EC/04

Marks Scale: 100 marks **Credit: 2**
(End Sem.: 75+ Int.: 25) **(L-T-P: 0- 0- 2)**

Objective: *The course gives an idea for the maintenance of laboratory and the practices that should be accomplished in a laboratory. The course explains how to prepare solutions and reagents, various methods of qualitative tests for proteins, carbohydrates and lipids.*

Course Outcome: *At the end of practical course, students will be able to carry out:*

- *qualitative tests for biomolecules, viz, proteins, carbohydrates, lipids.*
- *the students will equip themselves with the basic biochemistry techniques which can later applied for their laboratory research and also for many other industrial researches.*

One (1) experiment is to be performed within 3 hours in the End Semester examination. A minimum of 4 experiments is to be performed by the students.

1. Qualitative tests for carbohydrates (Solubility, reducing and non- reducing sugars, Identification of monosaccharides, disaccharides and polysaccharides).
2. Qualitative tests for Proteins (General tests and colour reactions of amino acids)
3. Qualitative tests for Lipids.
4. Qualitative tests for Nucleic acids.
5. Preparation of buffers, sodium/ phosphate/ acetate buffers.

THIRD SEMESTER
BCHEM - III: ENZYMOLOGY & BIOENERGETICS
Course No: BCHEM /III/EC/05

Marks Scale: 100 marks **Credit: 4**
(End Sem.: 75+ Int.: 25) **(L-T-P: 3- 1- 0)**

Objective*: The course is designed to enable students understand enzymes, properties, mechanism of action and regulation of their activity. To acquaint students grasp the basic cascades of energy transfer system and subsequent products in biology. The course will help the students understand fundamental energetics of biochemical processes, their functionalities.*

Course Outcome: *On completion of the course, students shall be able to:*

- *understand enzymes and how they catalyse reactions as well as enzyme kinetics.*
- *plan and carry out simple experiments on enzymes and physiology.*
- *Understand mechanism and concept of bioenergetics in cell biology*
- *Clear thermodynamics in relation to biological aspects*
- *Project carrying research works in M.Phil and PhD course.*

Unit 1: Introduction to enzymes
Classification and nomenclature of enzymes; Enzyme components: definition with examples - holoenzyme, apoenzyme, cofactors, prosthetic groups, coenzymes and their role in enzyme catalyzed reactions; Activators, inhibitors, Active site, Enzyme specificity, ES complex formation; Transition state theory; Activation energy.

Unit 2: Enzyme kinetics
Factors affecting enzyme activity: Derivation of Michaelis-Menten equation, Significance of K_m and V_{max}, Line Weaver-Burk plot; Enzyme inhibition – Reversible (competitive, non-competitive and uncompetitive inhibition) and irreversible inhibition. Allosteric enzymes.

Unit 3: Enzyme catalysis
Mechanism of Enzyme catalysis – acid-base catalysis, covalent catalysis, strain and distortion theory, chymotrypsin, carboxypeptidase and lysozyme; activation of latent enzymes, role of cofactors in enzyme catalysis: NAD/FAD+, FMN/FAD. Coenzyme A, biocytin, cobamide, lipoamide, TPP, pyridoxal phosphate, tetrahydrofolate and metal ions. Units of Enzyme activity.

Unit 4: Bioenergetics-I
Introduction to bioenergetics; Biological oxidation, Redox reactions in biology, Free energy. Electron Transfer Chain, Mechanism of ATP production, Oxidative Phosphorylation, Inhibitors and uncouplers.

Unit 5: Bioenergetics-II
Photosynthesis - hill reaction, light reaction, photosynthetic pigments, Z-scheme of photosynthetic electron flow. Photophosphorylation.
Laws of Thermodynamics and its application to biological systems.

References

1. Nelson, D.L. and Cox, M.M (2008). *Lehninger's Principles of Biochemistry*, Macmillan Pub.
2. Nicholas, C.P (1989). *Fundamentals of Enzymology*, Oxford University Press.
3. Jain, J.L., Sanjay, J and Nitin, J (1997). *Fundamentals of Biochemistry*, (6th ed.). New Delhi: S. Chand & company Ltd.
4. Rastogi, S.C (2006). *Experimental Physiology*, (2nd ed.). New Age Intl. (P) Ltd.
5. Colowick, S.P and Kaplan, N.O (1955). *Methods in Enzymology*, Vol. I and II. New York: Academia Press.
6. Rao, M.A (2006). *Medical Biochemistry*, (Revised 2nd ed.). New Age Intl. (P) Ltd.
7. Plummer, D.T (1993). *An Introduction to Practicals in Biochemistry*. Tata McGraw-Hill.
8. Boyer, R.F. (2005). *Modern Experimental Biochemistry*, (3rd ed.). Pearson-Educations (P) Ltd

THIRD SEMESTER
PRACTICAL –III
Course No: BCHEM III/EC/06

Marks Scale: 100 marks **Credit: 2**
(End Sem.: 75+ Int.: 25) **(L-T-P: 0- 0- 2)**

Objective: *The course seeks to provide understanding and applied knowledge of medical lab related biochemical tests. To understand the significance of enzyme reactions.*

Course Outcome: *At the end of practical course, students will be able to:*

- *carry out and understand enzymatic reactions*
- *understand factors affecting enzyme reactions.*

One (1) experiment is to be performed within 3 hours in the End Semester examination. A minimum of 4 experiments is to be performed by the students.

1. Effect of pH on the rate of enzyme reaction
2. Effect of temperature on the rate of enzyme reaction
3. Influence of substrate concentration and pH on the rate of enzymatic reaction
4. Determination of Km and Vmax of salivary amylase
5. Effect of enzyme concentration on enzyme activity

FOURTH SEMESTER

BCHEM - IV: INTERMEDIARY METABOLISM

Course No: BCHEM /IV/EC/07

Marks Scale: 100 marks **Credit: 4**
(End Sem.: 75+ Int.: 25) **(L-T-P: 3- 1- 0)**

Objective: *This course aims to develop a thorough knowledge among the students about metabolism. To enable students visualize energy production and utilisation in biological processes. The course gives metabolism of different biomolecules that can help students in understanding chemical pathway living system.*

Course Outcome: *On completion of the course, students shall be able to:*

- *identify and present relevant information from research publications dealing with issues of metabolism.*
- *assess and relate the information to the context of metabolism.*
- *understand the structure, catabolism & anabolism of biomolecules; interrelations, regulation & malfunction of the pathways associated with carbohydrate, protein, nucleotide and lipid metabolism.*

Unit 1: Introduction to Metabolism

General features of metabolism; anabolism and catabolism, metabolic principles; methods employed to study metabolism. ATP as energy currency. High energy phosphate compounds. Difference between anaerobic and aerobic ATP production, alcoholic & lactic acid fermentation.

Unit 2: Carbohydrate metabolism

Overview, reactions, regulations and energetics of Glycolysis and Tricarboxylic acid cycle. Amphibolic nature and anaplerotic reactions of TCA, Gluconeogenesis, HMP pathway and its significance.

Unit 3: Amino acid Metabolism

General reaction of amino acid degradation – Salient features and mechanism of Transamination. Deamination and decarboxylation. Metabolism of ammonia. Ketogenic and glucogenic amino acids. Urea cycle, regulation and its significance.

Unit 4: Lipid metabolism

Oxidation of fatty acids – α, β and ω types, β-oxidation of even number saturated fatty acids. Energetics of β-oxidation. Biosynthesis of even number saturated fatty acids. Ketone bodies formation. Outline of cholesterol metabolism.

Unit 5: Nucleotide metabolism

Sources of the atoms in the purine and pyrimidine molecules. *De novo* synthesis of purine and pyrimidine nucleotides and salvage pathways; degradation of purine and pyrimidine nucleotides; Regulation and inhibitors of nucleotide metabolism.

References

1. Powar, C.B (2010). *Cell Biology*. Himalaya Publishing House.
2. Verma, P.S and Agarwal, V.K (2004). *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology*, S. Chand & Company Ltd, New Delhi.
3. Gupta, P.K (2005). *Cell and Molecular biology*. Rastogi Publications, India.

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6. Voet, D., Voet, J.G and Charlotte, WP (2016). *Fundamentals of Biochemistry: Life at the Molecular Leve*l (5th ed.). Wiley ISBN 978-1-118-91840-1.

FOURTH SEMESTER
PRACTICAL -IV
Course No: BCHEM /IV/EC/08

Marks Scale: 100 marks **Credit: 2**
(End Sem.: 75+ Int.: 25) **(L-T-P: 0- 0- 2)**

Objective: *To train students on the basic techniques of biochemistry. The course gives hands on training on the practical experiments and techniques relating to metabolism in biochemistry.*

Course Outcomes: *At the end of this course,*

- *students will be able to analyse metabolic problems and will be able to approach a research problem specifically.*
- *will also help in understanding the significance of biochemical tests.*
- *Students will be able to carry biomolecular estimation based on the coloration reaction.*

One (1) experiment is to be performed within 3 hours in the End Semester examination. A minimum of 4 experiments is to be performed by the students.

1. Estimation of proteins by Biuret/Lowry method.
2. Estimation of carbohydrates by Anthrone method.
3. Isolation and estimation of starch from potato.
4. Isolation of casein from milk.
5. Isolation of lipids from egg yolk.

FIFTH SEMESTER
BCHEM - V: BIOCHEMICAL TECHNIQUES
Course No: BCHEM /V/CC/09

Marks Scale: 100 marks **Credit: 4**
(End Sem.: 75+ Int.: 25) **(L-T-P: 3- 1- 0)**

Objective: *The course is designed to train the students in biophysics and bioinstrumentation techniques essential for the understanding of life sciences and biotechnology. It is designed to make students get an idea on design of experiment using biophysical techniques. To make aware students giving the indispensability importance of modern techniques in biophysical research and living.*

Course outcome: *On completion of the course, students will be able to understand:*

- *biophysical techniques for carrying out research in life sciences.*
- *planning of experiment based on biophysical tools.*
- *microscopic observation and technique used in relation to immunology.*

Unit 1: pH and Photometry
pH meter – principle and applications. Electromagnetic spectrum. Principle, components (Lambert's Law, Beer's Law) and applications of colorimeter, spectrophotometer.

Unit 2: Chromatography
Introduction to chromatography. Principle and applications of Paper Chromatography, Ion-Exchange Chromatography, TLC, HPLC.

Unit 3: Centrifugation – Principles of centrifugation, concepts of RCF, preparative, differential and density gradient centrifugation, ultra-centrifugation.

Unit 4: Electrophoretic techniques
Introduction to electrophoresis; Principle and applications of agarose gel electrophoresis, SDS and native Polyacrylamide gel electrophoresis; factors affecting electrophoretic separation.

Unit 5: Microscopy and immunoassay
Microscopy – principle, components and applications; Light microscopy and electron microscopy. ELISA and RIA.

References

1. Primrose ,S.B and Twyman, R. M (2004). *Principles of Gene Manipulation and Genomics*, (7^{th} ed.). Blackwell publishing (Oxford, UK) ISBN:13: 978-1-4051-3544-3.
2. Satyanarayana, U. (2008). *Biotechnology*, (4^{th} ed.). Arunabha Sen Books and Allied (P) Ltd. (India). ISBN: 81-87134-90-9.
3. Upadhyay, A., Upadhyay, K and Nath, N (2014). *Biophysical Chemistry: Principles and Techniques*, (4^{th} ed.). Himalaya Publishing House, India.
4. Chawla, H.S (2002). *Introduction to plant Biotechnology*, (2^{nd} ed.). Oxford and IBH Publishing Co. Pvt.Ltd. (India). ISBN: 81-204-1549-3.
5. Michael, R.G and Sambrook, J (2014). *Molecular Cloning: A laboratory manual*, (4^{th} ed.). Cold spring Harbor laboratory press (vol-3.). ISBN: 978-1-936113-42-2.

6. David, P (1988). *A Textbook of Practical Biochemistry.* Tata McGraw- Hill Education.
7. Jayaraman, J. (1981). *Laboratory Mannual in Biochemistry*, (2nd ed.). New Age International Publishers.

FIFTH SEMESTER
PRACTICAL –V
Course No: BCHEM /V/CC/10

Marks Scale: 100 marks **Credit: 2**
(End Sem.: 75+ Int.: 25) **(L-T-P: 0- 0- 2)**

Objective: *The course is designed to offer different application of biochemical techniques critical in biological research. Students will be able to understand buffering system. Students will also learn techniques for protein separation and estimation.*

Course Outcome: *At the end of practical course, students will be able to carry out:*

- *separation of biomolecules using simple biochemical technique*
- *estimation of biomolecules*
- *practical based on microscopic observations.*

One (1) experiment is to be performed within 3 hours in the End Semester examination. A minimum of 4 experiments is to be performed by the students.

1. Determination of pH of a given solution using pH meter.
2. Demonstration of separation of lipids by TLC
3. Identification of amino acids by paper chromatography.
4. Separation of proteins by using SDS-PAGE.
5. Estimation of chlorophyll "a" and "b" from isolated chloroplast
6. To study the parts, handling and working of Microscope

FIFTH SEMESTER
BCHEM –VI: MICROBIOLOGY & IMMUNOLOGY
Course No: BCHEM /V/CC/11

Marks Scale: 100 marks **Credit: 4**
(End Sem.: 75+ Int.: 25) **(L-T-P: 3- 1- 0)**

Objectives: *The course is to introduce origin of microbiology, contribution of various scientists in the origin of microbiology. It will also give various salient features of microbes and the different methods of microbial culture techniques. This course is designed to impart the students the importance of immunology and its theoretical aspects and on the principles of immunology and immunotechnology. The application of immunology in medicines is also dealt with. It also explains the various antigen-antibody reactions involved in diseases, stem cell technology and vaccine development.*

Course Outcome: *At the end of the course the students will able to understand:*

- *origin of microbiology*
- *concept of microbial diversity and features*
- *culturing techniques and factors controlling microbial growth*
- *immune system and its concept*
- *antigen- antibody interaction system*
- *vaccines*

Unit 1: History and scope of Microbiology
Development of microbiology as a discipline, Spontaneous generation vs. biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Germ theory of disease.

Unit 2: Diversity of microbial world
General characteristics of different groups: acellular microorganisms (Viruses, Viroids, Prions) and Cellular microorganisms (Bacteria, Algae, Fungi and Protozoa) with emphasis on distribution and occurrence, morphology, mode of reproduction and economic importance.

Unit 3: Microbial nutrition and growth
Culture media; Synthetic or defined media, Complex media, Enriched media, Selective media, Differential media. Isolation of Pure culture: Streaking, Serial dilution and Plating methods, sterilization. Microbial Growth: phases of growth.

Unit 4: Immunology-I
Introduction to immunity; innate and adaptive immunity. Cells of Immunity; B and T lymphocytes. Immunoglobulins - structure and functions. Nature and types of antigens. Autoimmunity.

Unit 5: Immunology-II
Antigen-Antibody reaction. Hypersensitivity. Cell- mediated immune system and antibody mediated immune system. Vaccines - introduction and types.

References:

1. Kindt, T.L., Goldsby, R.A and Osborne, B.A (2007*). Kuby Immunology*, (6th ed.). W.H Freeman and Company (New York), ISBN: 13: 978-0-7167-8590-3 / ISBN: 10:0-7617-8590- 0.

2. Coico, R and Sunshine, G (2009). *Immunology: A Short Course*, (6th ed.). John Wiley& sons, Inc (New Jersey), ISBN: 978-0-470-08158-7.
3. Nigam, A and Ayyagiri, A (2008). *Lab Manual in Biochemistry, Immunology & Biotechnology*, Tata McGraw Hill.
4. Willey, J.M., Sherwood, L.M and Woolverton, C.J (2017). *Prescott's Microbiology*, (10th ed.), McGraw Hill Higher Education; ISBN13: 9781259657573.
5. Pelczar, Jr M.J., Chan, E.C.S and Krieg, N.R (2004). *Microbiology*, (5th ed.). Tata McGraw Hill; ISBN13: 9780074623206.142.
6. Cappucino, J. and Sherman, N. (2013). *Microbiology: A Laboratory Manual*, (10th ed.). Pearson Education Limited; ISBN13: 9780321840226.

FIFTH SEMESTER
PRACTICAL – VI
Course No: BCHEM /V/CC/12

Marks Scale: 100 marks **Credit: 2**
(End Sem.: 75+ Int.: 25) **(L-T-P: 0- 0- 2)**

Objective: *The course will feed students' understanding towards agglutination reactions in blood typing. They will be able to handle microbial culture and identification.*

Course outcome*: At the end of the course, students will be able to carry out:*

- *blood typing*
- *microbial culture media preparation*
- *isolation of microbes from the culture*
- *staining and screening of microbes*

One (1) experiment is to be performed within 3 hours in the End Semester examination. A minimum of 4 experiments is to be performed by the students.

1. Assays based on agglutination reactions - Blood typing (active) & passive agglutination.
2. Culture media preparation.
3. Isolation of bacteria from soil/water or air, counting CFU (Colony forming units).
4. Differential staining techniques.
5. Screening of microbes for production of catalase and oxidase enzymes.

FIFTH SEMESTER
BCHEM - VII: PHYSIOLOGICAL CHEMISTRY
Course No: BCHEM /V/CC/13

Marks Scale: 100 marks **Credit: 4**
(End Sem.: 75+ Int.: 25) **(L-T-P: 3- 1- 0)**

Objective*: To acquaint students with various aspects of physiological actions of selected organs which can be explained by particular biochemical processes. To understand fundamental mechanisms underlying normal function of cells, tissues, organs, and organ systems of the human body.*

Course Outcome: *On completion of the course, students shall be able to:*

- *gain knowledge on how the human body works and the importance of blood and its components and their interactions during a disease or imbalances.*
- *plan and carry out simple experiments on physiology.*

Unit 1: Physiology of blood
Homeostasis. Biochemistry of blood, plasma proteins. Blood group substances. Blood clotting and its mechanism. Blood cell types. Biochemical events in transport of CO_2 and O_2 in blood.

Unit 2: Physiology of excretion
Structure of kidney and nephron. Formation of urine; glomerular filtration, tubular re-absorption and secretion. Regulation of water and electrolyte balance. Acid- base balance.

Unit 3: Physiology of nerve
Structure and types of neurons. Resting membrane potential, Action potential, Transmission of nerve impulse across a synapse. Neurotransmitters and inhibitors of neurotransmission.

Unit 4: Physiology of muscle
Types of muscles and their structure. Ultra- structure of skeletal muscle. Contractile and regulatory proteins of muscle. Sliding filament model of skeletal muscle contraction.

Unit 5: Physiology of endocrine glands
Endocrine organs, classification of hormones. Functions of the hormones of hypothalamus, pituitary, adrenal, thyroid, pancreas and gonads. Mechanism of hormone action. Concept of messengers.

References

1. Nelson, D.L. and Cox, M.M (2008). *Lehninger's Principles of Biochemistry*, Macmillan Pub.
2. Jain, J.L., Sanjay, J and Nitin, J (1997). *Fundamentals of Biochemistry*, (6th ed.). New Delhi: S. Chand & company Ltd.
3. Rastogi, S.C (2006). *Experimental Physiology*, (2nd ed.). New Age Intl. (P) Ltd.
4. Rao, M.A (2006). *Medical Biochemistry*, (Revised 2nd ed.). New Age Intl. (P) Ltd.
5. H.R.Singh, Neeraj Kumar (2017). *Animal Physiology and Biochemistry,* (Revised 10th ed.). Vishal Publishing Co.
6. Plummer, D.T (1993). *An Introduction to Practicals in Biochemistry*. Tata McGraw-Hill.

7. Boyer, R.F. (2005). *Modern Experimental Biochemistry*, (3rd ed.). Pearson-Educations (P) Ltd.

FIFTH SEMESTER
PRACTICAL – VII
Course No: BCHEM /V/CC/14

Marks Scale: 100 marks **Credit: 2**
(End Sem.: 75+ Int.: 25) **(L-T-P: 0- 0- 2)**

Objective: *Physiology being at the core of medicine and health sciences, the study of the basic physiological tests will provide a thorough understanding of normal body functions. This course will equip the students to understand the experimental scientific disciplines for enabling a more effective diagnosis of abnormal or disease states.*

Course outcome: *On completing this course, the students will be able:*

- *to determine the various blood groups and the Rh status*
- *estimate the level of haemoglobin in blood.*
- *count WBC and RBC in blood and therefore identify their abnormal concentrations*
- *study about hormones based on biochemical tests*

One (1) experiment is to be performed within 3 hours in the End Semester examination. A minimum of 4 experiments is to be performed by the students.

1. Determination of ABO blood groups and Rh factor.
2. Estimation of blood Hemoglobin.
3. Counting of WBC using improved Neubauer's Chamber.
4. Counting of RBC using improved Neubauer's Chamber.
5. Collection of blood and separation of serum/ plasma.
6. Estimation of T3/T4.

FIFTH SEMESTER
Optional Paper I (any one)
BCHEM - VIII: CELL & MEMBRANE BIOLOGY
Course No: BCHEM /V/CC/15 (a)

Marks Scale: 100 marks **Credit: 4**
(End Sem.: 75+ Int.: 25) **(L-T-P: 3- 1- 0)**

Objective: *The study of cell biology aims to increase understanding of living systems and to consider the systems in relationship to the self and other organisms in the natural environment. The course gives the life activities at cellular and molecular level and basic functions of the various cellular compartments and organelles. This course also aims to develop knowledge among the students about signalling system in cell.*

Course Outcome: *On completion of the course, students shall be able to:*

- *identify and present relevant information from research publications dealing with issues of cell biology.*
- *assess and relate the information to the context of cell biology.*
- *gain knowledge on cell division and regulation*
- *plan and carry out simple experiments on the basis of cell.*

Unit 1: morphology of cell

Cell size, shape, comparison of prokaryotic and eukaryotic cell structure, cell types including cellular specialization and differentiation, differences in plant and animal cells. Cell theory. Cell motility – cilia and flagella.

Unit 2: Subcellular organelles

Structure and functions of subcellular organelles: nucleus, ER (RER and SER), Golgi apparatus, Mitochondria, Lysosomes, peroxisomes, chloroplast.

Unit III: Cytoskeleton and cell biology techniques

Microtubules, axonemal and cytoplasmic microtubules, Microfilaments: actin and myosin. Role of cytoskeletal elements in the entry of infectious agents.

Methods for studying cells and organelles - Phase contrast, staining freeze fracture techniques, Subcellular fractionation

Unit IV: Cell cycle:

Cell division (mitosis and meiosis); Cell cycle and its regulation, key concepts on apoptosis, necrosis and stem cells. Cancer- salient features and causes.

Unit V: Biological membrane

Flui-Mosaic model, fluidity of membranes. Membrane transport- uniport, symport, antiport, active and passive transport.

General overview of cell signaling; Types, signaling molecules and their receptors.

References

1. Powar, C.B (2010). *Cell Biology*. Himalaya Publishing House.
2. Verma, P.S and Agarwal, V.K (2004). *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology*, S. Chand & Company Ltd, New Delhi.
3. Gupta, P.K (2005). *Cell and Molecular biology*. Rastogi Publications, India.

4. Satyanarayana, U (2013*). Biochemistry*, (4th ed.). Reed Elsevier India Pvt. Ltd & Books and Allied Pvt Lmt. India. ISBN- 978-81-312-3601-7.
5. Nelson, D.L and Cox M.M (2008). *Lehninger's Principles of Biochemistry*, Macmillan Pub.
6. Voet, D., Voet, J.G and Charlotte, WP (2016). *Fundamentals of Biochemistry: Life at the Molecular Leve*l (5th ed.). Wiley ISBN 978-1-118-91840-1.

FIFTH SEMESTER
Optional Paper I (any one)
BCHEM - IX: GENETICS
Course No: BCHEM /V/CC/15 (b)

Marks Scale: 100 marks **Credit: 4**
(End Sem.: 75+ Int.: 25) **(L-T-P: 3- 1- 0)**

Objective: *The course is designed to explain the basic principles of Mendelian, population genetics and heredity and gives an overview on the classical genetics- Linkage & Crossing over, alleles,cytogenticts and evolutionary genetics.*

Course outcome: *At the end of this course, students will be able to understand:*

- *concept of Mendelism and inheritance*
- *cinkage, crossing over and cytogenetics*
- *genetics problems and allelic variations*
- *genetics of evolution.*

Unit 1: Mendelism & Chromosome Theory
Mendel's principles, applications of Mendel's principles, Chromosome Theory of Heredity (Sutton-Boveri), Inheritance patterns, phenomenon of Dominance, Inheritance patterns in Human (Sex-linked, Autosomal).

Unit 2: Linkage and crossing over
Chromosome theory of Linkage, kinds of linkage, linkage groups, types of Crossing over, mechanism of Meiotic Crossing over, kinds of Crossing over, significance of Crossing over.

Unit 3: Allelic Variations
Multiple allele, Genetic interaction, Epistatic interactions, Non-Epistatic inter-allelic genetic interactions, Atavism/Reversion, Penetrance (complete & incomplete), Expressivity, Pleiotropism)

Unit 4: Human pedigree analysis
Pedigree conventions, characteristics of dominant and recessive inheritance. Applications of pedigree analysis.

Unit 5: Evolutionary genetics
Molecular evolution - analysis of nucleotide and amino acid sequences, molecular phylogenies, homologous sequences, phenotypic evolution and speciation.

References

1. Tamarin, R (2010). *Principles of Genetics*, (7th ed.). Tata Mcgraw Hill Education.
2. Strickberger, W.M (2008). *Genetics*, (3rd ed.). Phi Learning publishing.
3. Simmons, M.J., Snustad, D.P and Gardner, E.J (2006). *Principles of Genetics*. Wiley publishing.
4. Lewin, B (2010*). Genes IX*. Jones & Bartlett Learning.
5. Paul, A (2007). *Text Book of Cell and Molecular Biology*, (2nd ed.). Books and allied (p) Ltd.
6. Kingston, H.M (2002). *ABC of Clinical Genetics*, (3rd ed.). BMJ Books.
7. *Genes and Disease* (1998). Bethesda (MD): National Centre for Biotechnology Information (US).

FIFTH SEMESTER
Project – I
Course No: BCHEM /V/CC/16

Marks Scale: 100 marks **Credit: 6**
(End Sem.: 75+ Int.: 25) **(L-T-P: 0- 0- 6)**
Practical/Project
Objective: *In order to gain practical knowledge on the theory they have studied, students will allow to conduct project work under the supervision of expertise teacher(s). Work plan will be made in which students will carry out experiment according to the objective of the project work.*
Course outcome: *On completion of the course, students will be able to understand:*

- *the atmosphere of research*
- *challenge of basic sciences in life sciences*
- *importance of research in the development of global community*

Project work based on Biochemistry to be assigned/ supervised by teachers, which is to be completed before End Semester examination.

SIXTH SEMESTER
BCHEM - X: CLINICAL BIOCHEMISTRY
Course No: BCHEM /VI/CC/17

Marks Scale: 100 marks **Credit: 4**
(End Sem.: 75+ Int.: 25) **(L-T-P: 3- 1- 0)**

Objectives: *Students will learn about the normal constituents of urine, blood and their significance in maintaining good health. Students will become aware with the variations in the levels of triglycerides and lipoproteins and their relationship with various diseases. Students will get acquainted with the role of enzymes in diagnosis of various diseases.*

Course outcome: *At the end of the course, the students will be able to:*

- *gain knowledge about the concepts of clinical biochemistry*
- *understand about the different biological samples, their collection and preservation*
- *develop an insight on the role of enzymes in diagnosis of certain diseases*
- *gain the importance of metabolism in understanding various diseases*

Unit 1: Basic concepts of clinical biochemistry

Basic concept of clinical biochemistry. Laboratory safety regulations and first aid. Units and abbreviations used in expressing concentrations and standard solutions. Quality control. Manual vs automation in clinical laboratory.

Unit 2: Collection and preservation of biological samples

Collection and preservation of biological samples (blood, serum, plasma, urine and CSF). Chemical analysis of blood, urine and CSF. Normal values for important constituents in blood (plasma/serum), CSF and urine.

Unit 3: Diagnostic enzymes

Definition of functional and non-functional plasma enzymes. Isozymes. Enzyme pattern in health and diseases (lipases, amylase, cholinesterase, alkaline and acid phosphatases, SGOT, SGPT, LDH and CPK.

Unit 4: Diagnostic tests

Organ Function Tests –Kidney, Liver.
Lipid profile – cholesterol, triglycerides, lipoproteins - HDL and LDL.

Unit 5: Diseases related to metabolism

Hypo- and hyper-glycemia, Diabetes mellitus. Fatty liver. Inborn errors of amino acid metabolism- alkaptonuria, phenylketonuria, albinism. Jaundice. Gout and hyper-uricemia.

References

1. Devlin, T.M (2011). Textbook of Biochemistry with Clinical Correlations. John Wiley & Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.
2. Chatterjee, M.N and Shinde, R (1995). Text book of Medical Biochemistry, (2nd ed.). Jaypee Brothers Medical publishers Private limited, New Delhi.
3. Burtis, Ashwood and TietZ W.B.S (1999). Textbook of Clinical Chemistry, (3rd ed.).

SIXTH SEMESTER
PRACTICAL - VIII
Course No: BCHEM /VI/CC/18

Marks Scale: 100 marks **Credit: 2**
(End Sem.: 75+ Int.: 25) **(L-T-P: 0- 0- 2)**

Objective: *The course is designed to help the students to understand the mechanisms of causation of liver, kidney and other diseases based on biochemical tests.*

Course outcome: *The learning outcomes include:*

- *qualitative and quantitative analysis of constituents of biological fluids such as urine, blood and their estimation using standard methods*

One (1) experiment is to be performed within 3 hours in the End Semester examination. A minimum of 4 experiments is to be performed by the students.

1. Collection of urine and qualitative analysis of normal constituents in urine
2. Estimation of blood Glucose by GOD/POD method.
3. Estimation of blood cholesterol by CHOD-PAP method
4. Estimation of bilirubin
5. Estimation of serum SGOT/ SGPT
6. Creatinine/ urea clearance test

.

SIXTH SEMESTER
BCHEM - XI: NUTRITIONAL BIOCHEMISTRY
Course No: BCHEM /VI/CC/19

Marks Scale: 100 marks **Credit: 4**
(End Sem.: 75+ Int.: 25) **(L-T-P: 3- 1- 0)**

Objective*: To provide information on concept of nutrition & health and understand the physiological and biochemical significance of micronutrients and macronutrients. This course will also help the student to know the clinical aspects of various disorders due to deficiency of nutrients.*

Course outcome: *At the end of the course, the students will be able to:*

- *understand the importance of nutrition, balance diet.*
- *gain knowledge on biochemical basis of digestion, absorption and transport of nutrients.*
- *gain knowledge by which mechanisms the nutritional related diseases arise.*

Unit 1: Basic concept of Nutrition
Nutrition and its importance. Concept of balance diet. Energy content of foods, BMR and SDA. Energy requirement during growth, pregnancy, lactation and various physiological conditions. Food adulteration.

Unit 2: Biochemical concept of nutrition
Nutritional importance of carbohydrates, fats, proteins and water. Digestion, absorption, and transport of - carbohydrates, lipids and proteins. Nitrogen balance. Positive and negative nitrogen balance. Probiotic.

Unit 3: Vitamins
Nutritional importance of vitamins, classification. Vitamins; dietary sources, RDA, biochemical role of Vitamin A, D, E, K, and C. Vitamin B- complexes.

Unit 4: Minerals
Nutritional importance of minerals, classification. Minerals; dietary sources, RDA, biochemical role of calcium, phosphorus, magnesium, sodium, potassium, iron and zinc.

Unit 5: Nutritional disorders
Kwashiorkor, Marasmus, Xerophthalmia. Rickets, Beri beri, Pellagra, Scurvy, iron-deficiency anaemia, goiter, obesity.

References

1. Mahan, L.K., Strings, S.E and Raymond, J (2012). Krause's Food and Nutrition Care process. Elsevier's Publications. ISBN- 978-1-4377-2233-8.
2. Tom, B. (1999). Nutritional Biochemistry, (2^{nd} ed.). Harcourt Braces publishing.
3. M. Swaminathan (2014). Handbook of Food and Nutrition. Bappco publishing.

FIFTH SEMESTER
PRACTICAL-IX
Course No: BCHEM /VI/CC/20

Marks Scale: 100 marks **Credit: 2**
(End Sem.: 75+ Int.: 25) **(L-T-P: 0- 0- 2)**

Objective: *The course is designed to provide students thorough ideas on food analysis and determination of minerals and vitamins in various foods.*

Course outcome*: On completion of the course, students will be able to:*

- *acquire expertise in calculation of BMI/BMR*
- *carry out analysis of different food samples.*
- *gain knowledge on detecting food adulterants and other food components.*

1. Calculation of BMI/BMR
2. Quantitative test for protein in food samples.
3. Quantitative test for carbohydrate in food samples.
4. Determination of moisture content of food.
5. Determination of adulterants in food.
6. Bioassay for vitamin B12/B1 by using colorimeter.

SIXTH SEMESTER
BCHEM - XII: MOLECULAR BIOLOGY
Course No: BCHEM /VI/CC/21

Marks Scale: 100 marks **Credit: 4**
(End Sem.: 75+ Int.: 25) **(L-T-P: 3- 1- 0)**

Objective: *The course explains the fundamental aspects of gene and genome organization to get basic knowledge to students. It also explains various molecular events in cell so that students can interestingly learn and project molecular status within the cell. The course gives an in-depth insight into the molecular aspects of life - the central dogma.*

Course Outcome: *On completion of the course, students shall be able to:*

- *identify and present relevant information dealing with issues of molecular biology.*
- *get an idea about the principles behind molecular biology which makes students to understand the basic molecular events in the cell.*
- *Understand occurrence of error and repair system in DNA.*

Unit 1: Genes and genomic organization

Genome sequence and chromosome diversity, definition of a gene, organization of genes in viruses, bacteria, animals and plants. Nucleosome structure and packaging of DNA into higher order structures.

Unit 2: DNA Replication

Evidence for DNA as genetic material; DNA replication in prokaryotes and experimental evidence for semiconservative DNA replication; Mechanism of replication-DNA polymerases, other enzymes involved in replication. Central Dogma in Molecular Biology.

Unit 3: Transcription & genetic code

Transcription in prokaryotes; RNA polymerase; Promoters; Initiation, elongation and termination of RNA synthesis; Reverse transcriptase; post-transcriptional processing of mRNA in eukaryotes (splicing, capping and polyadenylation) Genetic code: General features, Wobble hypothesis

Unit 4: Translation

Translation in prokaryotes; Ribosome structure; A and P sites, Charged tRNA; Initiator codon; elongation and termination; Formation of 70S initiation complex. Regulation of Gene Expression in Prokaryotes: Operon concept (Lac and Trp operon)

Unit 5: Mutations and repair

Concept of mutation, mutations induced by chemicals, radiation, transposable elements, Types of mutations - transition, transversions, and frame shift mutations.

Replication errors and mismatch repair system. Repair of DNA damage - direct repair, base excision repair, recombination repair.

References

1. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M and Losick, R (2008). *Molecular Biology of the Gene*, (6th ed.). Cold Spring Harbour Lab. Press, Pearson Pub.
2. Nelson, D.L and Cox M.M (2008). *Lehninger's Principles of Biochemistry*, Macmillan Pub.
3. Satyanarayana, U (2008). *Biotechnology*, (4th ed.). Arunabha Sen Books and Allied (P) Ltd. (India). ISBN: 81-87134-90-9.
4. Stryer, L (1995). *Biochemistry*, (4th ed.). W.H. Freeman Press, San Fransisco, USA.
5. Gupta, P.K. techniques(2005). *Cell and Molecular Biology*. Rastogi Publications.
6. Rastogi, S.C (2012). *Cell and Molecular Biology*, (3rd ed.). New age International Publishers, India.
7. Jeremy, M.B., John, L., Tymoczko and Stryer, L (2002). *Biochemistry*, (5th ed.) Freeman and Company New York ISBN-10: 0-7167-3051-0.
8. Voet, D., Voet, J.G and Charlotte, WP (2016). *Fundamentals of Biochemistry: Life at the Molecular Leve*l (5th ed.). Wiley ISBN 978-1-118-91840-1.

SIXTH SEMESTER
PRACTICAL - X
Course No: BCHEM /VI/CC/22

Marks Scale: 100 marks **Credit: 2**
(End Sem.: 75+ Int.: 25) **(L-T-P: 0- 0- 2)**

Objectives: *To understand the basics of molecular biology. To learn different methodologies in molecular biology. To enable students to design a cloning experiment and plant genetic improvement.*

Outcome Course*: At the end of the course, student will able to conduct:*

- *isolation of DNA from biological samples*
- *quantification of DNA samples*
- *amplification of DNA and analysis of amplified products.*

One (1) experiment is to be performed within 3 hours in the End Semester examination. A minimum of 4 experiments is to be performed by the students.

1. Isolation of DNA from plant/animal cells.
2. Agarose gel electrophoresis of DNA
3. Estimation of DNA by Diphenyl amine method
4. Estimation of RNA by Orcinal method
5. Determination of absorption maxima of nucleic acids
6. Amplification of a DNA fragment by PCR

SIXTH SEMESTER
Optional Paper II (any one)
BCHEM – XII: GENETIC ENGINEERING & BIOTECHNOLOGY
Course No: BCHEM /VI/CC/23 (a)

Marks Scale: 100 marks **Credit: 4**
(End Sem.: 75+ Int.: 25) **(L-T-P: 3- 1- 0)**

Objective: *The course is designed to illustrate creative use of modern tools and techniques for manipulation and analysis of genomic sequences. It will give students exposure to application of recombinant DNA technology in biotechnological research, giving ideas in strategizing research methodologies employing genetic engineering techniques. It will also give introduction to the various transformation techniques employed in plant system and application of genetically modified plants in the various fields of science.*

Course Outcome: *On completion of the course, students will be able to understand:*

- *concept of recombinant DNA technology*
- *tools and technique used in rDNA technology.*
  identification of cloned gene
- *application of recombinant DNA technology in various fields*

Unit 1: Introduction to recombinant DNA technology
History and scope of recombinant DNA technology, Restriction and modification systems, restriction endonucleases and other enzymes used in manipulating DNA molecules, blunt end and sticky ends.

Unit 2: Tools and techniques in genetic engineering
Cloning vectors – characteristic features, plasmid pBR322, M13, YAC and BAC. Basic steps in rDNA technology, Transfections of vectors into host cells. Genomic and cDNA library.

Unit 3: Nucleic acid hybridization
Principle of Nucleic acid hybridization, Principle and procedure of Southern, Northern and Western blotting, microarrays.

Unit 4: Amplifying DNA and sequencing techniques
PCR technology – principle, components and applications; DNA sequencing – Maxam-Gilbert, and Sanger-coulson methods. Human genome project.

Unit 5: Applications of genetic engineering
Production of recombinant pharmaceuticals such as insulin, human growth hormone, factor VIII. Applications in agriculture – transgenic crops (golden rice, Bt crops), ethical concerns, hybridoma technology.

References

1. Brown, T.A (2010). *Gene Cloning and DNA Analysis*, (6^{th} ed.) Wiley-Blackwell publishing (Oxford, UK), ISBN: 978-1-4051-8173-0.
2. Primrose, S.B and Twyman, R.M (2006). *Principles of Gene Manipulation and Genomics*, (7th ed.). Blackwell publishing (Oxford, UK). ISBN: 13: 978-1-4051-3544-3.

3. Satyanarayana, U. (2008). *Biotechnology*, (4th ed.). Arunabha Sen Books and Allied (P) Ltd. (India). ISBN: 81-87134-90-9.
4. Power, C.B (2013). *Genetic*s, (1st ed.). Himalaya Publishing House (India).
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6. Freifelder, D (1983). *Molecular Biology: A Comprehensive Introduction to Prokaryotes and Eukaryotes*, (2nd ed.).
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SIXTH SEMESTER
Optional Paper II (any one)
BCHEM - XIV: ENVIRONMENTAL BIOCHEMISTRY
Course No: BCHEM /VI/CC/23 (b)

Marks Scale: 100 marks **Credit: 4**
(End Sem.: 75+ Int.: 25) **(L-T-P: 3- 1- 0)**

Objective: *The course gives an introduction to the various aspects of environmental Biochemistry and explains the various applications of Biochemistry in the management and conservation of the environment. It also tries to explain the various environmental problems in terms of their Biochemical processes.*

Course Outcome: *On Completion of the course, the students will:*

- *obtain knowledge on basic principles and technologies of various contaminants and their management by means of biological approaches.*
- *know about the principles underpinning the application of biosciences to the environment.*

Unit 1: Types of Environmental pollutions
Biochemical effects of - air, water and soil pollution. Greenhouse gases and global warming.

Unit 2: Physiological effects of pollutants/ pollution
Toxic compounds in foodstuffs and water, Heavy metal poisoning, radioactive hazards, endocrine disrupting chemicals, antibiotic resistance.

Unit 3: Biological remedies for fighting pollution
Sewage treatment, phytoremediation, bioremediation, Green alternatives for fuels- biogas, biofuels, Green fertilizers – bio fertilizers, composting, vermicomposting.

Unit 4: Waste management
Treatment and methods of estimation of – domestic, industrial, hospital and agriculture.**Unit**

5: Physiological response to pollution
Plant response to heavy metals, microbial tolerance of heavy metals, mammalian detoxification of organic chemicals, tolerance to temperature change.

References

1. Satyanarayana, U (2008). Biotechnology, (4^{th} ed.). Arunabha Sen Books and Allied (P) Ltd. (India). ISBN: 81-87134-90-9.
2. Verma, P.S and Agarwal, V.K (2012). Environmental Biology (Principles of Ecology). S. Chand & Company Ltd, New Delhi.
3. Dubey, R.C (2014). A text book of Biotechnology. S.Chand Publications.
4. Environment, (6^{th} ed.). Shankar IAS Academy book publications. ISBN: 978-81-934226-0-1.

SIXTH SEMESTER
Project – II/Education Tour/Field Trip
Course No: BCHEM /VI/CC/24

Marks Scale: 100 marks **Credit: 6**
(End Sem.: 75+ Int.: 25) **(L-T-P: 0- 0- 6)**

Course objective: *The purpose of educational tour/ field trip is usually observation for education, non- experimental research. It will provide students an experience outside the classroom and laboratory.*

Course outcome: *On completion of the course, students will be able to understand/gain:*

- *The atmosphere of research*
- *Experience outside their everyday learning and activities*

Education tour which could help students in greater exposure under the guidance of teachers is to be allotted before completion of Final Semester examination.

Study tour within or outside the state (Mizoram) to be guided by teachers for outside laboratory experimentation, which is to be completed before Final Semester examination.