Dr. Ambedkar Veedhi, Central College Campus
Bengaluru-560001

Scheme and Syllabus

For

Biochemistry

for B. Sc. Degree with three majors

As per SEP 2024

for I and II Semesters

(With effect from 2024-25)

Department of Biochemistry,
Central College Campus
Bengaluru -560 001

June, 2024

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BENGALURU CITY UNIVERSITY

Department of Biochemistry,
Central College Campus, Bangalore -560001

Proceedings of the Meeting of Board of Studies in Biochemistry (UG), held on Wednesday, the 5th June, 2024 in the chambers of the Chairman, Dept. of Biochemistry, Central College Campus, Bangalore -560001

The meeting started with the Chairman welcoming the members and requesting the board to deliberate on the syllabus contents for B.Sc. Biochemistry UG course and propose the titles for all the six semester under SEP, and prepare the syllabus for the first two semesters. After a detailed discussion on the titles and contents, the board finalized the titles, and prepared the syllabi for I and II semester B.Sc. under the SEP scheme, effective from 2024-25. The meeting concluded with the chairman thanking the members for their valuable inputs and cooperation.

	Members Present		Signature
1.	Prof. V. R. Devaraj, Chairman, Dept. of Biochemistry, Bangalore University.	Chairman	
2	Dr. S. Kantharaju Dept. of Chemistry, SJRC College, Ananda Rao Circle Bangalore -560004	Member	
3.	Ms. Vidya, A.S. Dept. of Biochemistry, Seshadripuram College Yalahanka Bangalore -560064.	Member	
4.	Dr. (Mrs.) Myrene D'souza Dept. of Biochemistry, Mount Carmel College # 58, Palace Road, Bangalore – 560052	Member	

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5. Dr. R. Nagesh Babu, Member
Dept. of Chemistry,
Maharani's Science College for women,
Palace Road, Bangalore-560001

6. Ms. Malini. M·R Member
Dept. of Chemistry,
M.S Ramaiah College of Arts, Science & Commerce
Bangalore-54

7. Dr. Rajeev Ramachandra Kolagi Member
Dept. of Biochemistry,
Nrupathunga University
Bengaluru-560001.

8. Dr. Kamala, A. Member
Dept. of Biochemistry,
MLA College for women
Malleswaram 18th Cross
Bangalore-560004

9. Mrs. Ramya Kumari B.S Member
Dept. of Biochemistry
M.S Ramaiah College of Arts, Science & Commerce
Bangalore-54

10. Mrs. Madhukala. K.L Member
Dept. of biochemistry
Acharya B School,
Magadi Road,
Bengaluru-560091

11. Dr. Bhagyalakshmi Member
Dept. of biochemistry
University College of Science
Tumkur University
Tumkur-572101

12. Mrs. Savitha, K.R. Member
Dept. of biochemistry
University College of Science
Tumkur University
Tumkur-572101

SCHEME OF EXAMINATION

Title of the paper	Contact h/week	Exam. hours	I A	Marks	Total Marks	Credits
First Semester						
Biochemistry-I: BCT-01 Chemical Foundations of Biochemistry	4	3	20	80	100	3
Biochemistry practical-IBCP-01 Experimental Biophysical Chemistry	3	3	10	40	50	2
Second Semester						
Biochemistry-II: BCT-02 Bioorganic Chemistry	4	3	20	80	100	3
Biochemistry practical-II: BCP-02 Experimental Bioorganic Chemistry	3	3	10	40	50	2
Third Semester						
Biochemistry-III: BCT-03 Biochemistry of Macromolecules	4	3	20	80	100	3
Biochemistry practical-III: BCP-03 Qualitative and Quantitative analysis of Macromolecules	3	3	10	40	50	2
Fourth Semester						
Biochemistry-IV: BCT-03 Physiology & Cell Biology	4	3	30	70	100	3
Biochemistry practical-IV: Clinical Biochemistry and physiology	3	3	10	40	50	2
Fifth Semester						
Biochemistry-V: BCT-05 Biochemical Techniques	4	3	20	80	100	3
Biochemistry practical-V Bio-analytical methods	3	3	10	40	50	2
Biochemistry-VI: BCT-06: Bioenergetics & Metabolism	4	3	20	80	100	3
*Biochemistry Elective-1:BCOE-1** *Microbiology & Immunology*	3	1.5	10	40	50	2
Sixth Semester						
Biochemistry-VII: BCT-07: Enzymology	4	3	20	80	100	3
Biochemistry practical-VI:BCP-06 Enzymology	3	3	10	40	50	2
Biochemistry-VIII: BCT-08: Molecular biology	4	3	20	80	100	3
*Biochemistry Elective-2: BCOE-2** *Membrane Biochemistry*	3	1.5	10	40	50	2

Theory question paper pattern:

Each theory question paper has ***three Sections***;

1. 20% of the marks seeking short answers;
   Student has answer 8 out of 10 questions of 2 marks each

2. 40% of marks seeking medium size answers:
   Student has to answer 8 out of 10 questions of 4 marks each.

3. 40% of question seeking comprehensive answers:
   Student has to answer 4 out of 5 questions of 8 marks each.
   These questions may include sub questions (5+3).

Internal Assessment: Tests: 10 Marks (two internal tests to be conducted and average is considered for assessment)

Scheme of Practical Examination:

Duration	3 hours
Max. Marks	40 Marks
Marks for practical record	5 Marks
Marks for Viva-Voce	5 Marks
Marks for performing major experiment	20 Marks
Marks for performing minor experiment	**10** Marks

Assessment in Practical Examination

Awarding marks for performance	
Deviation of experimental values:	
0-5%	100% of allotted marks
6-10%	80% of allotted marks
11-20%	60% of allotted marks
20% and above	50% of allotted marks

Practical Record:

Recording 8 or more different experiments	5 Marks
Recording 6-7 different experiments	4 Marks
Recording 4-5 different experiments	3 Marks
Recording 3 different experiments	2 Marks
Recording Less than 3 experiments	0 Marks

Syllabus for Biochemistry major for B.Sc. Degree program with three majors

SEMESTER – I

Course title	Chemical Foundations of Biochemistry
Course Code	BCT -01
Course credits	3
Total contact hours	56
Duration of ESA	3
Formative assessment marks	20
Summative assessment marks	80

Learning outcomes:

This course will enable students to understand basic physical principles of biological systems, measurements in biochemical study, nature of chemical bonds. Also, helps them appreciate the physical properties of molecules, colloids, and basics of chemical kinetics essential for biochemistry.

Course content:

UNIT-I **15 Hours**

1. **Overview of Biochemistry:** Origin of Biochemistry as a discipline. Definition, scope and significance of Biochemistry. Chemical composition of living organisms.
2. **Units and Measurements:** Avogadro's number, mole, mole fraction, molarity, equivalent weight, normality, molality, percentage. Graphical representation of data – types of graphs. Errors in quantitative analysis –types, sources and minimizations. Precision and accuracy. Significant figures and its computation (Problems to be worked out).
3. **Properties of water:** Molecular structure of water (VSEPR theory), physical properties of water, its effect on biomolecules. Effect of non-polar compounds on water.
4. **Physical properties of molecules:** Adsorption -Definition, Freundlich and Langmuir's adsorption isotherm. Applications of adsorption. Viscosity-Definition, Experimental method of measuring viscosity of liquids and solutions by Ostwald's viscometer. Surface tension – Definition and its measurement. Distribution law - Distribution law, partition coefficient. Applications of distribution law.

UNIT-II

13 Hours

1. **Colligative properties:** Osmotic pressure and its measurements by Berkely and Hartley's method. Laws of osmotic pressure. Hypo, hyper and isotonic solutions. Effects of osmotic pressure on living cells. Donnan membrane equilibrium.
2. **Ionic equilibria:** Lewis concept of acids and bases. Ionic product of water. pH scale, buffers, Henderson-HasselBalch equation, buffer capacity, preparation of acidic and basic buffer solutions. Theory of acid base indicators. Choice of indicators. pH titration curves and isoelectric pH of amino acids. Electrodes (Hydrogen Electrode & Calomel electrode), glass electrode. Conductometric titrations [Strong acid against strong base, weak acid (amino acid) against NaOH. Measurement of pKa of amino acid by using pH meter.

UNIT-III

14 Hours

3. **Chemical bonding:** Types of bonds & bond characteristics - Ionic, covalent, co-ordinate bonds. Atomic orbitals and molecular orbitals – Molecular Orbital Theory, LCAO, bonding and anti-bonding of molecular orbitals, sp, sp2, sp3 and sp3d2 hybridizations with suitable examples. Sigma and pi bonds with examples. Van der Waal's forces, ion-dipole, dipole – dipole interactions, London forces, hydrophobic interaction, hydrogen bonding. Effect of chemical forces on physical properties (Solubility, BP and MP).
4. **Co-ordination compounds:** Transition metals, properties (Colour, oxidation states, magnetic properties). Co-ordinate bond, double and complex salts – differences with examples. Postulates of Werner's theory. Types of ligands – uni, bi and polydentate with examples. Co- ordination number. Porphyrin nucleus and classification. Important metalloporphyrins occurring in nature-structure and their biological importance (Hb, cytochrome, chlorophyll, Vitamin B12). Bile pigments – Types, structure and chemical nature.

UNIT- IV **14 Hours**

5. **Chemical kinetics**: Introduction, Rate of reactions, rate law or rate equation, molecularity and order of a reaction with examples, velocity constant or rate constant and half-life period expressions for zero, first and second order reactions with derivations (a=b and a ≠b), rate constant of irreversible reaction, kinetics of reversible reaction (without derivation). Numerical problems. Effect of temperature, pressure and catalyst on rate of reaction, Arrhenius equation and Arrhenius interpretation of energy of activation. Transition state theory with brief explanation.
6. **Colloids**: true solutions, classification, peptisation, purification, ultrafiltration, Brownian movements, electric properties, coagulation, mutual, lyophilic sols, boiling, dialysis, electro- and persistent dialysis, addition of electrolytes, colloids in daily life and

applications. Emulsion, types, micelles with biomolecules and its biological applications.

Suggested Readings:

- Puri, Sharma, Pathania Text Book Of Physical Chemistry
- Puri, Sharma, Pathania Text Book Of Inorganic Chemistry
- A Guide To Organic Reaction Mechanism- P. Sykes
- General &Inorganic Chemistry-R.P.Sarkar
- Inorganic Chemistry-R.L.Dutta
- New Concise Inorganic Chemistry-J.D.Lee
- F. A. Cotton & G. Wilkinson. Basic Inorganic Chemistry, John Wiley (1998)
- Douglas, Mcdaniel And Alexander: Concepts And Models In Inorganic Chemistry, John Wiley, 3rd Edition (1994).
- James E. Huheey, Ellen Keiter And Richard Keiter : Inorganic Chemistry: Principles Of Structure And Reactivity, Pearson Public, 4th Edition (2013).
- Pattabhi. V. And Gautham.N. (2002) Biophysics. Narosa Publishing House, India.

Course title	**Experimental Biophysical Chemistry**
Course Code	BCP- 01
Course credits	2
Total contact hours	42
Duration of ESA	3
Formative assessment marks	10
Summative assessment marks	40

Learning outcomes:

In this practical course, students will be introduced to laboratory exercises which provide skills to apply biophysical/chemical principles to understand biological processes. Also, helps them appreciate the physical properties of molecules, colloids, and basics of chemical kinetics essential for biochemistry.

Practical content:

1. Calibration of volumetric glassware (Burette, pipette and volumetric flask).
2. Preparation of standard sodium carbonate solution, standardization of HCl (Methyl orange) and estimation of NaOH in the given solution. (Methyl orange or phenolphthalein).
3. Preparation of standard oxalic acid. Standardization of NaOH and estimation of H_2SO_4 in the given solution (phenolphthalein).
4. Preparation of standard $K_2Cr_2O_7$. Standardization of $Na_2S_2O_3$ and estimation of $CuSO_4$ in the given solution.

5. Preparation of $ZnSO_4$. Standardization of EDTA and estimation of total hardness of water using eriochrome black-T indicator.
6. Preparation of standard potassium bipthalate. Standardization of NaOH and estimation of HCl in the given solution. (Phenolphthalein).
7. Calibration of pH meter and Preparation of buffers - acetate and phosphate buffers.
8. Conductometric titration of strong acid against strong base.
9. Conductometric titration of weak acid (amino acid) against strong base.
10. Determination of rate constant of decomposition of H_2O_2 using $KMnO_4$ by volumetric analysis method.
11. Determination of density and viscosity of the given liquid using specific gravity bottle and Ostwald's viscometer.
12. Determination of density and surface tension of the given liquid using specific gravity bottle and stalagmometer.

SEMESTER - II

Course title	BIO-ORGANIC CHEMISTRY
Course code	BCT-02
Course credits	03
Total contact hours	56
Duration of ESA	03
Formative assessment marks	20
Summative assessment marks	80

Learning outcomes:

This course helps the students to understand the significance of organic reactions and their relevance to biological systems. It help them gain a good understanding of aliphatic and aromatic compounds, nomenclature, reactivity of functional groups and the importance of stereoisomers in biological systems, and structure activity relationships in biomolecules.

Course Content:

UNIT-I **14 Hours**

1. **Introduction to organic chemistry**: Classification of organic compounds, unique characteristics, IUPAC nomenclature of organic compounds (including bi-functional) and biomolecules.
2. **Hydrocarbons**: Markownikoff and anti-Markownikoff addition. Addition of HBr to propene. Alkenes – Ozonolysis, oxidation. Dienes – types with examples, 1, 3 butadiene – Preparation, stability and mechanism of addition of HBr. Diels-Alder reaction. Conformational analysis of ethane.
3. **Reaction mechanisms:** Concept of inductive effect, resonance and hyperconjugation. Classification of organic reactions (substitution, addition, elimination and rearrangement), with two examples for each. Concepts of the following – carbanions, carbocations, free radicals, carbenes, nucleophiles and electrophiles (Formation and Stability).
4. **Alkyl halides and organometallic compounds:** SN^1, SN^2 and SN^i reactions, their mechanism with one example for each. Concept of elimination reactions (E^1, E^2 and E^1CB with an example). Organometallic compounds – definition and applications of organo lead, organo lithium, cis-platin.

UNIT-II **14 Hours**

5. **Arenes:** Structure of benzene – by Resonance and Molecular orbital theories.

Aromaticity (Huckel's rule). Mechanism of Nitration and Friedel- craft reaction. Electronic interpretation of the orientating influence of substituents in the electrophilic substitution of toluene, chlorobenzene, nitrobenzene and phenol. Resonance structures of naphthalene and anthracene.

6. **Stereochemistry:** Stereoisomerism, types, Fischer-projection formulae, chiral carbon atom, asymmetry and dissymmetry, chirality, conditions for optical isomerism ex: glyceraldehyde, lactic acid, tartaric acid, Nomenclature of enantiomers, diastereomers. D and L notation, R and S system, racemization and resolution (Biochemical, chemical and physical methods).Geometrical isomerism. E and Z notations.

UNIT-III

14 Hours

7. **Cycloalkanes:** Reactivity and relative stability. Bayer's strain theory. Sachse-Mohr theory. Boat and chair forms of cyclohexanes. Axial and equatorial bonds and their relation with biological activities of carbohydrates
8. **Alcohols:** Definition, classification, monohydric alcohols-distinguishing reactions for primary, secondary and tertiary alcohols. Dihydric alcohols: Glycol, preparation (any 2 methods) and uses. Trihydric alcohols: Glycerol, synthesis from propene, properties, (reaction with conc. H_2SO_4, HNO_3, Oxalic acid and HI). Phenols: Acidity of phenols, effect of substituent on acidity.
9. **Hydroxy acids and dicarboxylic acids:** Structure & properties of hydroxy acids: Lactic acid, citric acid and isocitric acid. Dicarboxylic acid: Maleic and fumaric acid. Ketoacids: Pyruvic, α-ketoglutaric, oxaloacetic acids.
10. **Carbonyl compounds:** General properties. Aldehydes and ketones. Keto-enol tautomerism, Mechanism: Claisen and aldol condensations. Quinones: Biologically important quinones.
11. **Amines:** Classification, properties, functional amino group – Basicity of amines, acylation. React with HNO_2 & Schiff's base formation. Distinguishing reactions of primary, secondary and tertiary amines.

UNIT-IV

14 Hours

12. **Heterocyclic compounds:** Definition, classification with examples, structure and biological importance of furan, pyrrole, thiophene, pyridine, pyran, thiazole, pyrimidine, purine, indole, imidazole, quinoline and isoquinoline. Basicity of pyrrole and pyridine.
13. **Terpenes:** Definition, isoprene rule, classification, isolation, structure and biological importance of menthol, camphor, farnesol, phytol, lanosterol, lycopene and dolichols.
14. **Steroids:** Basic ring structure in steroids. Structure and biological importance of cholesterol, phytosterols and ergosterol. Bile acids [Mono, Di & Tri cholic acids].
15. **Alkaloids:** Definition, classification based on their structure and biological functions,

isolation, structure and biological action of morphine, nicotine & atropine. Chemical synthesis of nicotine and atropine.

16. **Drugs**: Classification of drugs; synthesis and uses of sulphanilamide and paracetamol. Antibiotics: Definition; types; sources; structures and antimicrobial spectrum of action of penicillin, chloroamphenicol, streptomycin and tetracyclines.

Suggested Readings:

- Arun Bahl and B. S. Bahl: *Advanced Organic Chemistry,* S. Chand. (2019)
- L. Finar: *Organic Chemistry* (Vol. I & II), E. L. B. S. (2002)
- R. T. Morrison & R. N. Boyd: *Organic Chemistry*, Prentice Hall. (2011)
- Organic Chemistry (vol.1&2) – I. L. Finar
- Stereochemistry of Carbon Compounds- D. Nasipuri
- Basic Stereochemistry of Organic Compounds- S. Sengupta
- A Guide To Organic Reaction Mechanism- P. Sykes

Course title	**Experimental Bioorganic Chemistry**
Course code	**BCP-02**
Course credits	**02**
Total contact hours	**42**
Duration of ESA	**03**
Formative assessment marks	**10**
Summative assessment marks	**40**

Learning outcomes:

This laboratory course is aimed at imparting skills of identifying organic compounds, demonstrating reactivity of various functional groups, and synthesis of simple organic compounds of biological importance.

Practical content:

1. **Systematic qualitative analysis of the organic compounds:** Urea, glucose, benzamide, benzaldehyde, aniline, acetophenone, nitrobenzene, chlorobenzene, *p*-toluidine, benzoic acid, salicylic acid, resorcinol, and ethyl acetate.

2. **Organic preparations**: Aspirin from salicylic acid, benzoic acid from benzaldehyde, and meta-dinitrobenzene from nitrobenzene.

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BENGALURU CITY UNIVERSITY
BE BOUNDLESS

Dr. Ambedkar Veedhi, Central College Campus
Bengaluru-560001

Scheme and Syllabus

for

B.Sc. (Hons.) degree in Biochemistry and Discipline specific elective Course (CBCS) under NEP 2020

for III and IV Semesters

(With effect from 2021-22)

**Department of Biochemistry,
Central College Campus
Bengaluru -560 001**

September, 2022

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BENGALURU CITY UNIVERSITY
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BE BOUNDLESS

Department of Biochemistry,
Central College Campus, Bangalore -560001

Proceedings of the Meeting of Board of Studies in Biochemistry (UG), held on Tuesday the 3rd September, 2022 in the chambers of the Chairman, Dept. of Biochemistry, Central College Campus, Bangalore -560001

The meeting started with the Chairman welcoming the members to the meeting. The Charmin placed before the board, draft syllabus for III and IV semester B.Sc. Biochemistry proposed by the syllabus committee constituted by the Karnataka State Higher Education Council and the panel of examiners for the ensuing semesters and proposed Board of Examiners in Biochemistry (UG) for 2022-2023 examinations. The proposed syllabus and scheme was discussed in length and the board approved the same with minor additions and deletions taking into account the wholesome nature of concepts to be introduced. The board approved the panel of examiners and the BOE in Biochemistry (UG) for the 2022-2023. The meeting concluded with the chairman thanking the members for their valuable inputs and cooperation.

	Members Present		**Signature**
1.	Prof. V. R. Devaraj, Chairman, Dept. of Biochemistry, Bangalore University.	Chairman	3/9/2022
2	Dr. S. Kantharaju Dept. of Chemistry, SJRC College, Ananda Rao Circle Bangalore -560004	Member	3/9/22
3.	Ms. Vidya, A.S. Dept. of Biochemistry, Seshadripuram College Yalahanka Bangalore -560064.	Member	03/09/2022
4.	Dr. (Mrs.) Myrene D'souza Dept. of Biochemistry, Mount Carmel College # 58, Palace Road, Bangalore – 560052	Member	03/09/2022

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5. Dr. R. Nagesh Babu,
Dept. of Chemistry,
Maharani's Science College for women,
Palace Road, Bangalore-560001
Member ABSENT

6. Ms. Malini . M.R
Dept. of Chemistry,
M.S Ramaiah College of Arts, Science & Commerce
Bangalore-54
Member M.R 3/9/2022

7. Dr. Rajeev Ramachandra Kolagi
Dept. of Biochemistry,
Nrupathunga University
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Member ABSENT

8. Dr. Kamala, A.
Dept. of Biochemistry,
MLA College for women
Malleswaram 18th Cross
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Member kamala A 3/9/22

9. Mrs. Ramya Kumari B.S
Dept. of Biochemistry
M.S Ramaiah College of Arts, Science & Commerce
Bangalore-54
Member 03/09/22

10. Mrs. Madhukala. K.L.
Dept. of biochemistry
Acharya B School,
Magadi Road,
Bengaluru-560091
Member 3/9/22

11. Dr. Bhagyalakshmi
Dept. of biochemistry
University College of Science
Tumkur University
Tumkur-572101
Member 3/9/22

12. Mrs. Savitha, K.R.
Dept. of biochemistry
University College of Science
Tumkur University
Tumkur-572101
Member ABSENT

R. Devaraj
Dr. V.R. DEVARAJ, M.D.
Chairman
Dept. of Biochemistry
Bangaluru City University
Bangaluru - 560 001.

SEMESTER -III

Semester	**III**
Course title	**Bio-organic chemistry**
Course credits	**04**
Total contact hours	**56**
Duration of end semester assessment	**2.30 h**
Formative assessment marks	**40**
Summative assessment marks	**60**

Course Outcome:

These topics will enable students to understand the fundamentals of organic chemistry pertinent to their importance in understanding biochemical reactions.

Course Outcomes/Program Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
Aptitude	X	X	X	X								
Critical thinking		X										
Subject clarity	X	X				X	X	X		X		X
Analytical Skill	X				X	X	X	X	X			X

UNIT-1: Reaction mechanisms and aliphatic hydrocarbons: 1 4 hrs

Introduction, meaning of the term, kinetic and non-kinetic. Fundamental aspects: Homo and heterolytic cleavage. Concept of inductive effect, mesomeric effect, resonance and hyperconjugation. Classification of organic reactions (substitution, addition, elimination and re-arrangement), with two examples for each. Concepts reactive intermediates of the following – free radicals, carbocations and carbanions, carbenes, nucleophiles and electrophiles (Formation and Stability).

Hydrocarbons - Markownikoff's rule. Mechanism of addition of HCl to propene. Peroxide effect, Alkenes–Ozonolysis, oxidation. Alkynes–formation of acetylides and their importance. Dienes– types with examples. Conjugate dienes, 1, 3-butadiene – stability, mechanism of addition of HBr.

UNIT-2: Mechanism of Substitution, Elimination and Addition reactions 14 hrs

SN_1 and SN_2 reactions on tetrahedral carbon, energy profile diagrams, Stereochemistry, factors

affecting SN_1 and SN_2reactions.

The Elimination reactions- E_1, E_2 and E_{1cb} reaction, Zaitsev rule. Stereochemistry of E_1& E_2 reactions, E_1& E_2 elimination in cyclic compounds.

Addition reactions - Aldehydes and Ketones - nucleophilic addition of acetals & ketals. Addition of ammonia, primary amines and other ammonia derivatives. Conjugate addition – addition in alpha and beta unsaturated aldehydes and ketones, 1,2and 1,4 addition.

Carbonyl compounds General properties. Keto-enol tautomerism. Mechanisms: addition of HCN to acetaldehyde, Claisen and aldol condensations. Quinones: *o*- and *p*-benzoquinones- structure and properties.

UNIT-3: Mechanism of electrophilic aromatic substitution reactions 14 hrs

Aromatic compounds- aromaticity, criteria for aromaticity, anti-aromatic and non-aromatic compounds with examples. Mechanism of electrophilic aromatic substitution reactions- halogenation, nitration, sulfonation, Friedel Crafts alkylation and Friedel Crafts acylation. Relative reactivity of substituted benzenes, polycyclic benzenoid hydrocarbons.

Role of coenzymes – definition of coenzymes, Structure and role of thiamine pyrophosphate in decarboxylation of α-keto acids, Biotin in carboxylation of important biochemical reactions of carbohydrate and lipid metabolism.

VitB_{12}-roleinrearrangementreactions.

VitB_2- role in redox reactions with suitable examples.

UNIT–4: Bio-organic compounds 14 hrs

Alcohols: Classification, monohydric alcohols: examples, general and distinguishing reactions. Dihydric alcohols: glycols, Tri hydric alcohols: glycerol – synthesis from propene, properties and uses.

Phenols: Classification, electronic interpretation of acidity of phenols, mechanism of Kolbe, Reimer– Tiemann and bromination reactions.

Hydroxy acids: Structure & properties: lactic acid, citric acid and isocitric acid. Dicarboxylic acid: maleic and fumaric acid. Keto acids: pyruvic, α-ketoglutaric, oxaloacetic acid.

Amines: Classification, properties, functional group– Basicity of amines, acylation. Reaction with HNO_2 & Schiff's base formation. Distinguishing reactions of primary, secondary and tertiary amines.

Heterocyclic compounds: Definition, classification with examples, structure and biological importance of furan, pyrrole, thiophene, pyridine, pyran, thiazole, pyrimidine, purine, indole, imidazole. Aromaticity and basicity of pyrrole and pyridine.

Terpenes: Definition, Isoprene rule, classification, isolation. Structure and biological importance of menthol, camphor, farnesol, phytol, lanosterol, lycopene and dolichols.

Steroids: Basic ring structure in steroids. Structure and biological importance of cholesterol, phytosterols, ergosterol, cortisol, β-estradiol, testosterone, and aldosterone. Bile acids (Mono, Di & Tri cholic acids).

Alkaloids: Definition, classification based on their structure and biological functions, Isolation of alkaloids, structure and physiological action of morphine, nicotine and atropine.

REFERENCES:

1. Text book of Organic Chemistry 22nd Edition S. Chand Publishers 2019.
2. Organic Chemistry, Vol. I. Fundamental principles. I.L.Finar.6th Edn. ELBS, 2002.
3. Organic Mechanisms, Peter Sykes, Longman, 1977.
4. Organic Chemistry R.T. Morrison and R.N. Boyd, 6th Edn. Prentice Hall, India, 2018.
5. Lehninger Principles of Biochemistry; DL Nelson and MM Cox [Eds), 6th Edn. Macmillan Publications, 2012.
6. Chemistry-An Introduction to General, Organic and Biological Chemistry,7th Edn. Karen C. Timberlake, Benjamin Cummings, 1999.
7. Reaction Mechanisms at a glance, M. Moloney (Ed.), Blackwell Science 2000.

PEDAGOGY: **Mooc/Deskwork/Book chapter/Problem solving/Assignment**

Formative Assessment	
Assessment occasion	**Weightage in marks**
Class test (2 class tests)	**20**
Seminars/class work	**10**
Assignment/open discussion	**10**
Total	**40**

SEMESTER – III; Practical-III

Course title	**Bio-organic chemistry**
Course credits	**02**
Total contact hours	**4 Hours/Week**
Duration of end semester assessment	**03 h**
Formative assessment marks	**25**
Summative assessment marks	**25**

Course Outcome:

This course aims to familiarize students with the principles of organic chemistry and basic Qualitative analysis of organic compounds. Course Objective is to provide experimental practice of preparation of organic compounds and extraction of biologically important compounds.

Experiments:

I. Systematic Qualitative Analysis of organic compound (6 practicals)

1.Urea	2.Glucose	3. Aniline
4.BenzoicAcid	5.Salicylicacid	6.Benzaldehyde
7.Acetophenone	8.Chlorobenzene	9.Nitrobenzene

II. Preparation of the following organic compounds (2 practical's)

1. Acetylation: Preparation of acetyl salicylic acid from salicylic acid.
2. Oxidation: Preparation of benzoic acid from benzaldehyde.
3. Nitration: Preparation of *m*-dinitrobenzene from nitrobenzene.
4. Hydrolysis: Preparation of benzoic acid from ethyl benzoate.

III. Extractions:

1. Extraction of caffeine from tea leaves
2. Extraction of starch from potatoes
3. Extraction of casein from milk.

REFERENCES:

1. Practical Organic Chemistry: Qualitative Analysis by S.P. Bhutani, A.Chhikara2009
2. Textbook of Practical Organic Chemistry Including Qualitative Organic Analysis by Arthur Israel Vogel, 2003
3. Comprehensive practical organic chemistry-Preparation and quantitative analysis, V.K. Ahluwalia and Renu Aggarwal, 2004.
4. Practical Hand Book of Systematic Organic Qualitative Analysis. Md. Rageeb Md. Usman, S. S. Patil, 2017.
5. Laboratory Manual of Inorganic & Organic Chemistry (Qualitative Analysis) Kalpa Mandal, Sonia Ratnani, 2020.

PEDAGOGY: Mooc/Deskwork/Book chapter/Problem solving/Assignment

Formative Assessment	
Assessment occasion	**Weightage in marks**
Continuous evaluation and class test	**15**
Record/ viva-voce	**10**
Total	**25**

SEMESTER III; Open Elective –1

Course title	Biochemical Techniques
Course credits	03
Total contact hours	42 h/week
Duration of end semester assessment	2.30 h
Formative assessment marks	40
Summative assessment marks	60

Course Outcome:

- Develop competence in handling various chromatographic, electrophoretic and isotope techniques and apply them in isolating and characterizing different biological molecules

UNIT-1 **14 hrs**

Microscopy: Different types of microscopes– Principle and applications of light microscope. Electron microscopy– TEM, SEM, applications. Fluorescence and confocal microscopes used in fine structure studies.

Centrifugation Techniques: Introduction, basic principle and applications of sedimentation. Centrifuges and their use- small bench centrifuges, refrigerated centrifuges– large capacity and high speed, continuous flow centrifuges, ultracentrifuge- preparative and analytical and density gradient centrifuge.

UNIT– 2 **14 hrs**

Chromatography: Introduction, classification of chromatographic techniques. Principle and applications of paper chromatography, Thin layer chromatography (TLC), Column chromatography- Adsorption chromatography, Gel-permeation, Ion exchange chromatography, Affinity chromatography, Gas chromatography (GC), High performance/pressure liquid chromatography (HPLC).

Electrophoresis Techniques: Introduction, principle and applications of electrophoretic techniques- Paper electrophoresis, starch-gel electrophoresis, polyacrylamide gel electrophoresis (native and SDS), agarose gel electrophoresis, isoelectric focusing, isotachophoresis.

UNIT– 3 **14 hrs**

Isotope Techniques: Introduction to isotopes; radioisotopes. Radioactive decay, Units of radioactivity, Measurement of radioactivity-GM counters, Scintillation counters, autoradiography. Applications of radioisotopes in the biological Sciences.

Spectroscopy: Introduction, Nature of electromagnetic radiations. Beer-Lamberts law. Principle and applications of spectroscopic techniques in biochemical investigation- UV-Vis spectroscopy, Colorimetry, Fluorescence spectroscopy, Infrared spectroscopy, Circular dichroism (CD) spectroscopy, Electron spin resonance (ESR), Atomic Absorption spectroscopy (AAS), Nuclear Magnetic resonance (NMR) spectroscopy and Mass spectroscopy.

REFERENCES:

1. Modern experimental Biochemistry: Rodney Boyer, 3rd Edn. Benjamin Cummings, 2000.
2. Practical Skills in Biomolecular Sciences: R Reed, D.Holmes, JWeyersand A.Jones 1998
3. Physical Biochemistry: David Frifielder 2nd Edition, 1983.
4. Biophysical chemistry Upadya and Upadya, 2016.
5. Introductory practical Biochemistry: SK Sawhney and Randhir Singh, 2001.

PEDAGOGY: Mooc/Deskwork/Book chapter/Problem solving/Assignment

Formative Assessment	
Assessment occasion	**Weightage in marks**
Class test (2 class tests)	**20**
Seminars/class work	**10**
Assignment/open discussion	**10**
Total	**40**

SEMESTER – III; Open Elective-2

Course title	**Hormones; Biochemistry and function**
Course credits	**03**
Total contact hours	**42**
Duration of end semester assessment	**03**
Formative assessment marks	**40**
Summative assessment marks	**60**

Course Outcome:

- Understand the function of hormones and their regulation.
- Know how hormonal systems act in an integrated manner to regulate overall body functions.
- Understand how failure of these normal physiologic functions and integrations are associated with some endocrine disorders.

UNIT–1: Signaling **14 hrs**

Introduction to the concept of systems. Hormones– definition, classification (origin, chemical nature, location and mechanism of action) and intercellular communication. Chemical signaling-endocrine, paracrine, autocrine, and neuro-endocrine mechanisms. Mechanism of hormone action: synergism, antagonism, permissive effects. Physiological role of pituitary, pineal, thyroid and parathyroid hormones. Introduction to the hypothalamus as the true master gland with releasing hormones and inhibitory substances. Neuro-hypophysis and its secretions– ADH and oxytocin. Outline of feedback regulation of secretion of hormones. Overview on signal transduction pathways for steroidal and non-steroidal hormones (one example each).

UNIT– 2: Physiology of hormone action **14 hrs**

Physiological role of pancreas, adrenal, and placenta. Introduction to Gastrointestinal hormones and neurotransmitters (Acetyl Choline, GABA, Serotonin). Mechanism of action, target tissues, and the physiological effects of gastrointestinal hormones. Structure and functions of sex hormones. Hormones during ovarian and uterine phases of menstrual cycle; placental hormones; role of hormones during parturition and lactation. Hormone receptors: receptors in the cell membrane and in the cell. Secondary and tertiary messengers (cAMP and Ca^{+2}).

UNIT– 3 **14 hrs**

Clinical endocrinology-Blood, plasma, serum- Separation and storage. Methods of hormone estimation, assay systems, normal range of hormones in tissues and clinical conditions leading to abnormal levels with interpretations. Thyroid function test- Determination of T3, T4, and TSH. Infertility profile: Determination of LH, FSH, TSH, estrogen, progesterone, total testosterone, free testosterone. Major manifestations of disease of the endocrine pancreas, thyroid, hypothalamus and pituitary disease.

REFERENCES:

1. Norman AW, Litwack G (1997), Hormones, 2nd Edition, Elsevier Publications.
2. Bolander F (2004), Molecular Endocrinology, 3rd Edition, Elsevier Publications.
3. Rifai N (2007),Teitz Fundamentals of Clinical Chemistry, 6th Edition, Elsevier Publications.
4. Henry's Clinical Diagnosis and Management by Laboratory Methods (2011), 22nd Edition, Elsevier.
5. Vasudevan DM (2011), Text book of Medical Biochemistry, 6th Edition, Jaypee Publishers.
6. Chatterjea MN & Shinde R (2012), Text book of Medical Biochemistry, 8th Edition, Jaypee Publications.
7. Bishop ML, Fody EP, Schoeff LE (2013), Clinical Chemistry: Principles, Techniques, and Correlations,7th Edition, Wiley Publications.
8. JN Singh (2017), Biochemistry General, Hormonal and Clinical-1st Edition, Atithi books Publishers.
9. Rifai N (2017), Teitz Text book of Clinical Chemistry and Molecular Diagnostics, 6th Edition, Saunders Publications.

PEDAGOGY: Mooc/Deskwork/Book chapter/Problem solving/Assignment

Formative Assessment	
Assessment occasion	**Weightage in marks**
Class test (2 class tests)	20
Seminars/class work	10
Assignment/open discussion	10
Total	40

SEMESTER –IV

Semester	**IV**
Course title	**Analytical Biochemistry**
Course credits	**04**
Total contact hours	**56**
Duration of end semester assessment	**2.30 h**
Formative assessment marks	**40**
Summative assessment marks	**60**

Course Outcome:

- Understanding the concept of Biochemical analyzing instruments both automated and semi automated.
- To learn about how to Care & Maintenance of Equipment & Chemicals.
- To learn normal ranges of biochemical components in our body.
- Clinically relevant biochemical analysis for deeper understanding of all biochemical components i.e., Proteins, Electrolytes, Hormones etc.
- Basic knowledge of clinical and forensic analytical methods and their principles.

Course Outcomes/ Program Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
Aptitude	X	X	X	X								
Critical thinking		X				X						
Subject clarity	X	X						X				X
Analytical Skill				X	X	X	X	X	X	X	X	X

UNIT-1: Biological sample preparation and fractionation 14hrs

Introduction and objectives of bioanalysis and extraction of molecules from tissues and cells. Sample preparation types of sample- live, postmortem extraction of macromolecules from tissues; fractionation - liquid-liquid, liquid-solid and precipitation methods.

Centrifugation- Introduction, principles of centrifugation, angular velocity, sedimentation, sedimentation coefficient, centrifugal field, relative centrifugal field. types of centrifugation- Preparative and analytical. Differential, density gradient and ultra-centrifugation. Basic instrumentation; types of rotors and their design. Laboratory centrifuge; operational instruction and applications. Analytical centrifuges-Optics; Application in sub-cellular fractionation. Care and maintenance of instrument.

UNIT-2: Chromatography **14 hrs**

History of chromatography. General principle of chromatography. Classification based on stationary and mobile phase- Planar and column chromatography, based on types of mobile and/or liquid phase- adsorption and partition- Gas chromatography and liquid chromatography. Based on stationary phase- thin layer chromatography, Paper chromatography–Ascending, descending and circular, 2-D chromatography, Rf value.

Principles, methodologies and applications of adsorption-, partition-, ion-exchange-, gel-filtration- and affinity-chromatography. Advanced chromatography- working principle and applications of HPLC, FPLC, UPLC and GLC.

UNIT-3: Electrophoretic and radio-isotopic methods **14hrs**

Electrophoresis- General principle of electrophoresis, velocity of a charged molecule in the applied electric field, relevance of Ohm's law in electrophoretic separations. Supporting media for electrophoresis; work of Tiselius, paper, cellulose acetate, agarose, poly acrylamide. Chemistry of polymerization of acrylamide gels, methodology and applications of native PAGE and SDS-PAGE, 2-D electrophoresis. Identification of proteins post electrophoresis- dyes and in-gel biological activities. Applications of agarose gel, pulse field electrophoresis, capillary electrophoresis and isoelectric focusing. Principle and applications of immuno-electrophoresis.

Radioisotopic methods: Radioactivity–Types of radioactive decay, Properties of α, β, γ radiations. Group displacement law. Decay law- decay constant, Half-life period and average life of a radioactive element. Detection of radioactivity – GM counter and scintillation counters (only principal and working). Applications of radioisotopes– ^{3}H, ^{14}C, ^{131}I, ^{60}Co and ^{32}P. Biological effects of radiations. Radio labelling, safety measures in handling radio isotopes.

UNIT–4: Spectroscopy **14 hrs**

Wave particle duality of light, electromagnetic spectrum. Beer's law and its limitations, determination of molar absorption coefficient of molecules. Principle, design and application of colorimeter and UV-Vis spectrophotometer. Working principle and application of flame photometer and fluorimeter. Principle and application of IR, Raman, ESR, NMR, AAS and Mass spectroscopy.

REFERENCES:

1. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan. Springer, 2011.
2. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 8th Edn. Andreas Hoffman and Samuel Clockie,(Eds)., Cambridge University Press, 2018.
3. Biochemistry and Molecular Biology; 5th Edn. D. Papachristodoulou, A. Snape, W.H. Elliott, and D.C. Elliott, Oxford University Press, 2014.

PEDAGOGY: Mooc/Deskwork/Book chapter/Problem solving/Assignment

Formative assessment	
Assessment occasion	**Weightage in marks**
Class test (2 class tests)	**20**
Seminars/class work	**10**
Assignment/open discussion	**10**
Total	**40**

SEMESTER – IV; Practical-IV

Course title	**Analytical Biochemistry**
Course credits	**02**
Total contact hours	**4 hours/week**
Duration of end semester assessment	**03 h**
Formative assessment marks	**25**
Summative assessment marks	**25**

Course Outcome:

The Course Objective is to provide experimental practice of analytical techniques in Biochemistry. Upon successful completion, students should develop skills in handling instruments and understand its application in research work.

- Sourcing and handling biological samples. Develop skill and proficiency in basic techniques;
- Centrifugation,
- Chromatography,
- Electrophoresis and
- Spectroscopy.

Experiments:

1. Isolation of human lymphocytes using clinical centrifuge.
2. Determination of packed cell volume/hematocrit.
3. Separation of basic, acidic and aromatic amino acids by ascending/descending and circular paper chromatography.
4. Separation of plant pigments by gel-permeation chromatography.
5. Separation of lipids by thin layer chromatography.
6. Determination of void volume of a gel-filtration column.
7. Recording the absorption spectrum of riboflavin and determination of λ_{max}.
8. Colorimetric estimation of glucose by DNS method.
9. Estimation of DNA by diphenylamine method.
10. Electrophoretic separation of plasma proteins.

REFERENCES:

1. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan, Springer, 2011.
2. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 8th Edn. Andreas Hoffman and Samuel Clockie, (Ed.), Cambridge University Press, 2018.
3. Biochemistry and Molecular Biology; 5th Edn. D. Papachristodoulou, A. Snape, W.H. Elliott, and D.C. Elliott, Oxford University Press, 2014.

PEDAGOGY: Mooc/Deskwork/Book chapter/Problem solving/Assignment

Formative assessment	
Assessment occasion	**Weightage in marks**
Continuous valuation and class test	**15**
Record/ viva-voce	**10**
Total	**25**

SEMESTER – IV; Open Elective-1
Biochemical Toxicology

Course title	**Biochemical Toxicology**
Course credits	**03**
Total contact hours	**42**
Duration of end semester assessment	**2.3 h**
Formative assessment marks	**40**
Summative assessment marks	**60**

Course Outcome:
This open elective course offered to various streams gives basic idea about biochemical basis of various effects of toxins/ pharmaceuticals and an outline of process involved in toxicity testing and drug dosing.

- Categorize the classes of toxicants/drugs and know specific examples
- State the routes of exposure to toxins/drugs;
- Explain the processes of absorption, metabolism and elimination of toxins/drugs; and
- Explainenvironmentalandphysiologicalfactorsthataffecttoxicantmetabolism

UNIT–1 Fundamentals of Toxicology and Dose response 14 hrs

Scope of toxicology; why should we know about toxins/xenobiotics (drugs) and what makes a substance toxic? Grading toxicity, use of animal studies for toxicity, *in vitro* toxicity, organ toxicity (liver and kidney toxicity). Indicators of toxicity/drug effects; biomarkers. Concentration and site of action, dose response, effect of route of administration, ED_{50}, LD_{50}/TD_{50}. Hazard and risk assessment, risk management, acceptable daily intake (ADI) and tolerable daily intake (TDI).

UNIT– 2 Disposition of Toxins 14 hrs

Outline of ADME process - toxin/drug uptake, entry into cells and systemic circulation. Effect of size, shape, solubility, and charge on their uptake. Major sites of absorption – skin, intestine, and liver. Role of transporters and plasma proteins in distribution. Plasma levels of toxins/drugs, plasma half-life. Excretion-kidney, biliary excretion. Metabolism-types of metabolic changes of foreign compounds, biotransformation/detoxification reactions, phase-1 and, phase -2 reactions. Nature of phase-1and phase-2 enzymes.

UNIT-3 Targets of toxic damages and Biochemical Mechanism of toxicity 14hrs

Damage caused by toxins/drugs on liver, kidney, gall bladder and lungs. Methods of identifying the damages. Mechanism of biochemical toxicity; chemical carcinogens- benzo[a]pyrene, tamoxifen.

Liver necrosis: carbon tetrachloride, valproic Acid, and iproniazid, Kidney damage: chloroform, antibiotics- gentamycin,

Lung damage: 4-Ipomeanol,

Neurotoxicity: isoniazid, parquet, primaquine, cyclophosphamide.

REFERENCES:

1. Biopharmaceuticals Biochemistry and Biotechnology 2nd Edn. Gary Walsh, John Wiley & Sons, Ltd, England, 2003.
2. Fundamentals of Experimental Pharmacology, Ghosh, M.N. 2nd Edition, Scientific Book Agency, Kolkatta,1984.
3. Introduction to Biochemical Toxicology, 3rd Edn., Ernest Hodgson, Robert C. Smart; Wiley-Interscience; 2001.
4. Principles of Biochemical Toxicology, John A. Timbrell, 4th Edn. 2009, Taylor & Francis
5. Remington Pharmaceutical Sciences, Lippincott, Williams and Wilkins, 2000.

PEDAGOGY: Mooc/Deskwork/Book chapter/Problem solving/Assignment

Formative assessment	
Assessment occasion	**Weightage in marks**
Class test(2 class tests)	**20**
Seminars/class work	**10**
Assignment/open discussion	**10**
Total	**40**

SEMESTER – IV; Open Elective-2

Plant Biochemistry

Course title	**Plant Biochemistry**
Course credits	**03**
Total contact hours	**42 h**
Duration offend semester assessment	**2.30 h**
Formative assessment marks	**40**
Summative assessment marks	**60**

Outcomes:

- Understand the plant cell, photosynthesis, transporters and important primary metabolites.
- Illustrate plant growth regulators, plant's responses to various biotic and abiotic stresses.
- Explain about plant secondary metabolites and their functional importance.

UNIT-1 **14 hrs**

Plant cell- structure and molecular components: Cytoskeleton, an overview. Plant cell division, cell cycle. Outlines of energy production in plant cells, Carbon assimilation and nitrogen assimilation.

An overview of photosynthesis; C3, C4 plants and crassulacean acid metabolism (CAM); photorespiration; Phytochromes, cryptochromes and phototropins. Non-protein thiols and sulfur cycle.

Plant cell membranes and membrane transport: Introduction to plant cell membranes and membrane constituents. Organization of transport systems across plant membranes; Different types of transporters in plant cell and organelle membranes; classification and importance of H^+-ATPases. Ion channels- properties and significance; Aquaporins and water transport.

Important primary metabolites of plants: Properties, function and applications of cellulose, starch, sucrose, oligosaccharides; fructans, gums, mucilages, poly unsaturated fatty acids, lignin, suberin, surface waxes, sulfides and sweet proteins.

UNIT-2 **14 hrs**

Plant growth regulators: Role of auxins, cytokinins, gibberellins, abscisic acid, ethylene, brassinosteroids, polyamines, jasmonic acid and salicylic acid.

Plant responses to biotic stresses: Introduction; plant pathogens and diseases; plant defense systems-hypersensitive response; systemic acquired resistance; induced systemic resistance; Plant biotic stress response to pathogensand insects.

Plant responses to abiotic stress- Salt stress, drought and heavy metal stress responses; osmotic adjustment and significance of osmotic agents such as proline, sugar alcohols and quaternary ammonium compounds. An overview of oxidative stress and oxidative damage – antioxidant enzymes and stress tolerance.

UNIT-3 **14 hrs**

Plant Secondary Metabolites

Introduction and definition. An overview of primary metabolism contribution to secondary metabolites biosynthesis. Classification of plant secondary metabolites.

Alkaloids: General characteristics and classification with examples. Contribution of amino acids for alkaloid biosynthesis. Isolation and purification of alkaloids. (S)-Seticuline-the chemical chameleon.

Phenolics: General characteristics and classification with examples- flavonoids and anthocyanins. Isolation and purification of phenolics.

Terpenoids: General characteristics and classification with examples. Isoprene rule. Isolation and purification of terpenoids.

Applications of secondary metabolites: in plants'defense; in insects' signalling, morphogenesis and defense. Physiologically active secondary metabolites in modern medicine and therapeutic compounds for human ailments.

REFERENCES:

1. Lehninger's Principles of Biochemistry-Nelson & Cox. CBS Publishers & Distributors, 2013.

2. Principles of Biochemistry-Moran, Horton, Scrimgeour, Perry. Pearson, 5th Edition , 2011.

3. Plant Biochemistry, P.M. Dey & J.B. Harborne. Hart Court Asia Pvt Ltd.,1997.
4. Plant Biochemistry and Molecular Biology; P.Lea & Richard C Leegood, John Wiley & Sons, 1999.
5. Introduction to Plant Biochemistry; Goodwin and Mercer, CBS Publisher and Distributors, 2005.
6. Biochemistry and Molecular Biology of Plants; Buchanan, Greussem and Jones, American Society of Plant Physiologists, 2000.
7. Natural Products from plants; Peter B. Kaufman, Lel and J. Cseke, Sara Warber, James A. Duke, HarryL. Brielmann, CRC Press, Boca Raton, 1999.
8. Natural Products Targeting Clinically Relevant Enzymes. Paula B. Andrade, Patricia Valentao David M. Pereira. Wiley-VCH Verlag GmbH & Co., 2017.
9. Plant Cell Tissue and Organ Culture: Fundamental Methods; O.L. Gamborg & G.C. Phillips, Narosa Publishers, New Delhi , 1995.
10. Kant R. Sweet proteins; Potential replacement for artificial low calorie sweeteners. Nutrition J. 2005; 4:5 doi:10.1186/1475-2891-4-5.
11. MisakaT. Molecular mechanisms of the action of miraculin, a taste-modifying protein. Seminars Cell Develop Biol. 24:222-225, 2013.
12. Temussi PA. Natural sweet macromolecules: how sweet proteins work. Cell Molec Life Sci CMLS.63:1876-1888, 2006.

PEDAGOGY: Mooc/Deskwork/Book chapter/Problem solving/Assignment

Formative assessment	
Assessment occasion	**Weightage in marks**
Class test (2 class tests)	**20**
Seminars/class work	**10**
Assignment/open discussion	**10**
Total	**40**

B.Sc. III & IV SEMESTERS MODEL QUESTION PAPER
BIOCHEMISTRY

Time:2.5 h Max.marks:60

Note: all sections are compulsory

SECTION – A

1. Answer any FIVE of the following 5x2= 10
   a.
   b.
   c.
   d.
   e.
   f.
   g.

SECTION –B

Answer any FOUR of the following; 4x5= 20

2.
3.
4.
5.
6.
7.

SECTION – C

Answer any THREE Questions 3 x 10 = 30

8.
9.
10.
11.
12.

Note*: Section C may include sub questions, a, and b*

B.Sc. III & IV SEMESTERS MODEL QUESTION PAPER

BIOCHEMISTRY OPEN ELECTIVE

TIME: 2.30 h **Max. marks: 60**

Note: all sections are compulsory

SECTION – A

1. Answer any FIVE of the following 5x2= 10
   a.
   b.
   c.
   d.
   e.
   f.
   g.

SECTION –B

Answer any FOUR of the following; 4 x5=20

2.
3.
4.
5.
6.
7.

SECTION – C

Answer any THREE Questions 3 x10 = 30

8.
9.
10.
11.
12.

Note*: section C may include sub questions a, and b*

INTERNAL ASSESMENT (as on 4th October meeting proceedings)

DISCIPLINE CORE	DISCIPLINE/OPEN ELECTIVE	PRACTICLAS
60+40 (IA)	60+40 (IA)	25+25 (IA)
Class Test -20	Class Test -20	Continuous evaluation & class test -15
Seminars/Classwork-10	Seminars/Classwork –10	Record/Viva-10
Assignment/Open discussion-10	Assignment/Open discussion-10	

BENGALURU CITY UNIVERSITY

CHOICE BASED CREDIT SYSTEM

(Semester Scheme with Multiple Entry and Exit Options for Under Graduate Course)

Syllabus for Biochemistry
(V & VI Semester)

2023-24

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BENGALURU CITY UNIVERSITY

Department of Biochemistry, Central College Campus, Bangalore -560001

Proceedings of the Meeting of Board of Studies in Biochemistry (UG), held on Thursday the 17th August, 2023 in the chambers of the Chairman, Dept. of Biochemistry, Central College Campus, Bangalore -560001

The meeting scheduled to discuss the V and VI semester B.Sc. Biochemistry course started with the Chairman welcoming the members. The Chairman placed before the board, draft syllabus for V and VI semester B.Sc. Biochemistry proposed by the syllabus committee constituted by the Karnataka State Higher Education Council and guidelines for preparing two major scheme. The proposed syllabus and scheme was discussed in length and the board approved the syllabus conforming to two major patterns. The meeting concluded with the chairman thanking the members for their valuable inputs and cooperation.

Members Present		**Signature**
1. Prof. V. R. Devaraj, Chairman, Dept. of Biochemistry, Bangalore University.	Chairman	
2 Dr. S. Kantharaju Dept. of Chemistry, SJRC College, Ananda Rao Circle Bangalore -560004	Member	Absent
3. Ms. Vidya, A.S. Dept. of Biochemistry, Seshadripuram College Yalahanka Bangalore -560064.	Member	
4. Dr. (Mrs.) Myrene D'souza Dept. of Biochemistry, Mount Carmel College # 58, Palace Road, Bangalore – 560052	Member	

....2

5. Dr. R. Nagesh Babu, Member
Dept. of Chemistry,
Maharani's Science College for women,
Palace Road, Bangalore-560001

6. Ms. Malini M.R Member
Dept. of Chemistry,
M.S Ramaiah College of Arts, Science & Commerce
Bangalore-54

7. Dr. Rajeev Ramachandra Kolagi Member
Dept. of Biochemistry,
Nrupathunga University
Bengaluru-560001.

8. Dr. Kamala, A. Member
Dept. of Biochemistry,
MLA College for women
Malleswaram 18th Cross
Bangalore-560004

9. Mrs. Ramya Kumari B.S Member
Dept. of Biochemistry
M.S Ramaiah College of Arts, Science & Commerce
Bangalore-54

10. Mrs. Madhukala. Member
Dept. of biochemistry
Acharya B School,
Magadi Road,
Bengaluru-560091

11. Dr. Bhagyalakshmi Member
Dept. of biochemistry
University College of Science
Tumkur University
Tumkur-572101

12. Mrs. Savitha, K.R. Member
Dept. of biochemistry
University College of Science
Tumkur University
Tumkur-572101

SEMESTERV-V

Semester	**V**
Course title	**Biochemistry of macromolecules**
Course credits	**04**
Total contact hours	**56**
Duration of end semester assessment	**2.30 h**
Formative assessment marks	**40**
Summative assessment marks	**60**

Course Outcome:

The course provides fundamental insights on the types of macromolecules; and unique structural features, chemical properties and biological importance of each.

CourseOutcomes	1	2	3	4	5	6	7	8	9	10	11	12
Aptitude	x	x	x	x								
Criticalthinking		x								x		x
Subjectclarity	x	x					x					x
AnalyticalSkill	x				x	x				x		

UNIT-I **14 hours**

Carbohydrates

Definition, empirical formulae, classification, biological importance.

Monosaccharides: Configuration relationship of D-aldoses, D-ketoses. General properties of aldoses and ketoses. Oxidation, reduction, reducing property, formation of glycosides, acylation, methylation, condensation–phenylhydrazine, addition HCN. Interconversion of aldoses and ketoses by chemical method. Stereochemistry of monosaccharides, (+) and (-), D and L, epimers, anomers, and diastreoisomers. Elucidation of open chain structure and ring structure of glucose. Conformation of glucose (only structures), mutarotation. Structure of galactose, mannose, ribose and fructose. Structure and biological importance of deoxy sugars and sugar acids.

Disaccharides:EstablishmentofstructuresofSucroseandLactose,Biological Importance and structure of Isomaltose, Trehalose and Maltose.

Polysaccharides: Partial structure, occurrence and importance of Starch, Glycogen,Inulin, Cellulose, Chitin, and Pectin.

Glycosaminoglycans: Structure of amino sugars, neuraminic and muramic acid. Occurrence, importance and the structure of the repeating units of heparin, hyaluronic acid, teichoic acid and chondroitin sulphate. Bacterial cell wall polysaccharide, peptidoglycans.

UNIT-II: **14 hours**

Lipids

Classification and biological role, fatty acids – nomenclature of saturated and unsaturated fatty acids.

Acylglycerols: Mono-, di- and triacylglycerols. Saponification, saponification value, iodine value, acid value and significance. Rancidity– types.

Phosphoglycerides: Structure of lecithin (phosphatidyl choline), cephalins, phosphatidyl inositol, plasmalogens, and cardiolipin. Biological role of phosphoglycerides.

Sphingolipids:Structureandimportanceofsphingomyelin.

Glycerosphingolipids: Composition and importance of gangliosides andcerebrosides. Prostaglandins: Types, structure of PGE2, PGI2, PGD2 and PGF2α. Biological roles of thromboxanes, leukotrienes and prostaglandins.

Plasma lipoproteins: Composition, types and functions – clinical significance.

UNIT-III **14 hours**

Amino acids and Proteins

Amino acids: Structure and classification of amino acids based on polarity. Reactions oftheaminogroupswithHNO_2,$LiAlH_4$.Ninhydrin,Phenylisothiocyante, Dansyl chloride, Fluoro-dinitro benzene. Reaction of carboxyl group – Hydrazine. Zwitterionic properties. pKa values, D-& L- notation.

Peptides: Peptide bond, geometry and bond parameters, Ramachandran plot.Structure and biological importance of peptides; glutathione, Valinomycin. Synthetic peptides- polyglutamic acid, and polylysine.

Proteins: Classification of proteins based on solubility, structure and functions with examples. Forces that stabilize the structure of proteins. Primary structure of proteins, methods of determining N- and C- terminal aminoacids, sequencing by Edman's degradation method. Secondary structure–α-helix, β-sheet β-bend. Tertiary and quaternary structures-hemoglobin. Denaturation and renaturation of proteins; Anfinsen's experiment.

UNIT-IV **14hours**

Nucleic acids

Composition of DNA and RNA. Nucleosides and Nucleotides. Other functions of nucleotides– source of energy, component of coenzymes and secondary messengers.Chargaff's rule. Watson and Crick model of DNA. Forms of DNA and their interconversions. Nucleic acid chemistry-UV absorption, hypochromic and hyperchromic effects. Effect of alkali and acid on DNA, Chemical reactions of RNA and DNA.Melting of DNA (Tm).Types of RNA (snRNA, mRNA, tRNA and rRNA), Secondary structure of tRNA – clover leaf model.

REFERENCES

1. Principles of Biochemistry, Donald Voet, Judith G Voet, Charlotte W.Pratt, 4th Edition, John Wiley and Sons Inc, 2012.
2. Lehninger-Principles of Biochemistry; D L Nelson and MM Cox (Eds), 6th Edn. Macmillan Publications, 2012.
3. Biochemistry-the chemical reactions of living cells, David E Metzler, 2nd Edition, Elsevier Academic Press,
4. Fundamentals of Biochemistry, Jain, J.L,S.Chandpublication 6th Edition, 2005.
5. Biochemistry, Jeremy M. Berg, John L. Tymoczko, Lubert Stryer, Freeman & co., 7th Edition, 2010.
6. Harper's Illustrated Biochemistry, Victor Rodwell et. ,al, 31st edition,McGrawHill Education Lange ® 2018.
7. Biochemistry,10th edn., Jeremy M. Berg, John L. Tymoczko, LubertStryer, Gregory J. Gatto, Jr., mcmillan Education, 2023.

8. Text Book of Biochemistry with Clinical correlations; Thomas Devlin [Ed.] (1999), Wiley -Liss.
9. Principles of Biochemistry H. Robert Horton, Laurence A. Moran, K. Gray Scrimgeour, J. David Rawn, Pearson College, 2006.

PEDAGOGY: **Mooc/Deskwork/Book chapter/Problem solving/Assignment**

Formative Assessment	
Assessment occasion	**Weightage in marks**
Class test(2 class tests)	**20**
Seminars/class work	**10**
Assignment/open discussion	**10**
Total	**40**

SEMESTER – V; Practical-V

Course Title	**Qualitativeanalysisof Macromolecules**
Course credits	**02**
Total contact hours	**4 Hours/Week**
Duration of end semester assessment	**03 h**
Formative assessment marks	**25**
Summative assessment marks	**25**

Course Outcome

- The practical course will enable the students to learn the principles of reactions pertaining to different macromolecules. They will be able to qualitatively identify the presence of specific macromolecules or amino acids when provided with solution of a mixture of biomolecules.

EXPERIMENTS

1. **Carbohydrates:** monosaccharides (glucose, fructose, galactose) disaccharides(lactose, maltose, sucrose) and polysaccharides (starch, glycogen), ribose, deoxy ribose- Molisch Test, Iodine test, Benedict's test, Barfoed's test, Seliwanoff's test, Bial's test, DPA Test, Tollen'stest, Fehling's test, Picric Acid test, Osazone test.
2. **Proteins:** Biuret Test, Ninhydrin Test, Precipitation reactions of proteins- Precipitation by salts (half-saturation test), precipitation by organic solvents, precipitation by acidic reagents, precipitation by heavy metal ion, precipitation by heat; colour reactions of proteins (gelatin and albumin) and any five amino acids (tryptophan, tyrosine, cysteine, methionine, arginine, proline and histidine)- Xanthoproteic test, Millon's Test, Sakaguchi Test, Hopkins- Cole Test, Lead acetate test, Sullivan and McCarthy's Test, Isatin Test, Pauly's Diazo Test.
3. **Lipids:**solubility,acroleintest,Salkowskitest,Lieberman-Burchardtest.
4. **Nucleic acids:** diphenylamine test, orcinol test.

PEDAGOGY: Mooc/Deskwork/Book chapter/Problem solving/Assignment

Formative Assessment	
Assessment occasion	**Weightage in marks**
Continuous evaluation and class test	**15**
Record/ viva-voce	**10**
Total	**25**

REFERENCES

1. Practical Biochemistry, Geetha Damodaran, Jaypee, 2011
2. Biochemical Methods,S.Sadasivam,A.Manickam,3rd Edition, New Age International Pvt Ltd, 2007.
3. An Introduction to Practical Biochemistry, David Plummer,3rd edition, 2017.
4. Laboratory Manual in Biochemistry, J. Jayaraman,2011.

SEMESTER-V

Course credits	Human physiology and Enzymology
Course credits	**04**
Total contact hours	**56 h**
Duration of ESA	**2.30 h**
Formative assessment marks	**40**
Summative assessment marks	**60**

Course Outcome:

- Describe cell structure and functions, how cells form and divide, and how they differentiate and specialize.
- Students will be able to describe the cyclical events of cell division and types ofcell divisions. Student'sknowledge with regard to the process of cell death and cell aging will enhance to its core.
- Physiologyinvolvesthestudyofhowlivingsystems function, fromthe molecular and cellular level tothesystem level, and emphasizes an integrative approach to studying the biological functions of the human body.
- Enzymology topics will enable students to describe structure, functions and themechanism of action of enzymes. Learning kinetics of enzyme catalyzed reactionsand enzyme inhibitions and regulatory process, Enzyme activity, Enzyme Units,Specific activity.

CourseOutcomes	1	2	3	4	5	6	7	8	9	10	11	12
Aptitude	x	x	x									
Critical thinking		x										
Subject clarity	x	x									x	
Analytical Skill	x				x	x						

UNIT-I **14 hours**

Basic body plan in humans & Location of organs.

Nervous System: Brief outline of nervous system, Neurons – types, structure of multipolar neuron, mechanism of nerve impulse transmission- along axon, across synapse. Resting membrane potential and Action potential. Neurotransmitters – Excitatory & Inhibitory with examples.

Respiratory system: Anatomy, structure and functions of lungs, mechanism of respiration(pulmonary ventilation), gas exchange mechanism, biochemical events in the transportofgases & factors affecting, role of lungs in acid-base balance. Bohr's effect. Hypoxia, emphysema.

Cardio-vascular system: Structure and functions of heart. Blood vessels–types, Overview & functions: Cardiac cycle, cardiac output, regulation of CVS, blood pressure, heart rate, ECG. Body fluids–blood (composition and functions of blood and plasma), Lymph and CSF. Blood clotting mechanism.

Muscular System: Types of muscles and their structure. Ultra-structure of skeletal muscle. Contractile & regulatory proteins of muscle. Sliding filament modelof skeletalmuscle contraction.

UNIT-II **14 hours**

Connective tissue: Types and functions of connective tissue.Structure and types of bone and cartilage. Long bone – Composition, structure, growth& remodeling, factors affecting.

Digestive System and GIT: Digestion, absorption & transport of carbohydrates, lipids and proteins. Role of various enzymes involved in digestive process. Microbiota of GIT and its significance.

Hepatic System: Structure of a liver lobule. Role of liver in metabolic, storage and detoxification.

Excretory System: Brief outline of excretory system, formation of urine – Glomerularfiltration, tubularreabsorption and secretions. Roleofkidneyinacid-base balance. Regulation of kidney function.

Endocrine System: Brief outline of various endocrine glands and their secretions. Dynamicbalance and regulation of hormonal secretions. Classification of hormones basedon structure and site of production. Physiological role of hormones of hypothalamus, pituitary, adrenal, thyroid, pancreas and gonads. Regulationoftheir secretion.

UNIT-III **14 hours**

Introduction to enzymes

Nature of enzymes - protein and non-protein (ribozyme). Cofactor and prostheticgroup, apoenzyme, holoenzyme, IUBMB classification of enzymes withexamples. International Units of enzyme activity, specific activity.

Monomeric and oligomeric enzymes- Monomeric enzymes, multifunctional enzymes,

oligomeric enzymes and multi- enzyme complexes, isoenzymes- lactatedehydrogenase.

Features of enzyme catalysis:

Catalysis, reaction rates and thermodynamics of reaction. Enzyme as catalyst. Activation energy and transition state theory, catalytic power and specificity of enzymes (concept of active site), Theories of enzyme catalysis- Fischer's lock and key hypothesis, Koshland's induced fit hypothesis.

UNIT- IV **14 hours**

Enzyme kinetics of single substrate reactions

Review of Law of Mass Action. Equilibrium constant, mono substrate reactions,relationship between initial velocity and substrate concentration,derivation of Michaelis-Menten equation. Lineweaver- Burk plot. Determination of Vmax & Km and their significance, Kcat and turnover number. Factors affecting the rate of reaction- enzyme concentration, substrate concentration, pH, temperature, inhibitors and activators (including metal ions).

Reversible inhibition- competitive, uncompetitive, non-competitive, mixed and substrate inhibition with graphicalrepresentations using L-B plots, Evaluation of Km and Vmax in presence of inhibitor.

Irreversible inhibition- Suicide inhibition. Antibiotics asinhibitors- penicillin.

REFERENCES

1. Chatterjee, C C, Human physiology, Medical allied Agency. New Delhi 2020.
2. Gerard J Tortora, Bryan H Derrickson. Principles of anatomy and physiology, 13th edition, John Wiley & Sons 2000.
3. Gyton and Hall,Textbook of Medical physiology, 10thedition,ElsevierHealth Sciences 2015
4. Sembulingam K& Prema Sembulingam, Essentials of medical physiology, 3rd edition, Jaypee Brothers, 2019.
5. ThomasD.Pollard, WilliamC.Earnshaw,Jennifer Lippincott-Schwartzand Graham T. Johnson, Cell Biology, 3rd edition, Elsevier 2017
6. Lodish, Berk, Kaiser,Krieger et. al, Molecular Cell Biology, 6thedition, 2010
7. Bruce Alberts, Hopkin, Johnson Morgan, Raff, Roberts, and Walter, Essential Cell Biology, 5th edition, W.W. Norton & Company, 2019
8. Palmer, Understanding enzymes, 4th edition, Prentice Hall/Ellis Horward, Landon 2000.
9. Price, Nicholas C., and Lewis Stevens. Fundamentals of Enzymology. Oxford Science Publications. Second edition. New York, 2010

PEDAGOGY: MOOC/DESK WORK/BOOK CHAPTER/PROBLEM SOLVING /ASSIGNMENT

Formative Assessment	
Assessment occasion	**Weightage in marks**
Class test (2 class test)	**20**
Seminars/Class work	**10**
Assignment/Open discussion	**10**
Total	**40**

SEMESTER-V; Practical -VI

Course title	Humanphysiologyand Enzymology Practical
Course credits	**02**
Contact hours	**4 h/week**
Duration of ESA	**03 h**
Formative assessment marks	**25**
Summative assessment marks	**25**

Course Outcome:

At completion of this course, it is expected that the students will be able to: Determining the blood grouping and other physiological parameters, Identification of microscopical features of various types of cells and tissues: Understand the anatomy & Physiology of various systems and learn the various cells anddemonstrate the principle and working ofinstruments used in cell biology.

EXPERIMENTS:

1. Determination of ABO blood grouping
2. Determination of Blood clotting time
3. Enumeration of RBC and WBC count using Hemocytometer
4. Separation of Serum and Plasma from Blood
5. Estimation of hemoglobin in content in blood
6. Study of pulmonary function test using spirometer
7. Salivary amylase/β- amylase
   a) Construction of Maltose/glucose calibration curve by DNS method anddetermination of activity of amylase
   b) Determination of specific activity of amylase
   c) Determination of pH optimum of amylase.
   d) Determination of Km and Vmax of amylase.
   e) Determination of optimum temperature of amylase.
   f) Effect of sodium chloride on amylase.
8. Determination of activity of yeast invertase.
9. Isolation of Urease and demonstration of its activity.

REFERENCES

1. Essentials of Medical Physiology, K. Sembulingamand P.Sembulingam. Jaypee Brothers medical publishers, New Delhi., 2019
2. Text book of Medical Physiology-C, Guyton and John.E.Hall, Miamisburg,OH, U.S.A, 12th edition 2011.
3. Text book of Practical Physiology, C.L. Ghai, Jaypee brother's Medical Publishers, New Delhi, 10th edition 2022.
4. AHandbookofpracticalMicrobiology, R. Saravanan , D. Dhachinamoorthi , CH. M M. Prasada Rao , 2019.

PEDAGOGY: MOOC/DESK WORK/BOOK CHAPTER/PROBLEM SOLVING/ASSIGNMENT

Formative Assessment	
Assessment Occasion	**Weightage in marks**
Record/Viva-Voce	**10**
Continuous Evaluation and Class Test	**15**
Total	**25**

SEMESTER-VI

Course title	Molecular Biology and Immunology
Course credits	**04**
Total contact hours	**56**
Duration of ESA	**2.5 h**
Formative assessment marks	**40**
Summative assessment marks	**60**
Course credits	**04**

Course Outcome:

These topics will enable students to understand the molecular mechanisms, via which genetic information is stored, expressed and transmitted among generations. Students will be able to define the concept of immunology and concepts of antigen and antibody, explain immune system cells,discuss active immunity, passive immunity and cellular immune mechanism.

CourseOutcomes	1	2	3	4	5	6	7	8	9	10	11	12
Aptitude	x	x	x									
Critical thinking		x										
Subject clarity	x	x				x					X	X
Analytical Skill	x				x	x				X		

UNIT-I

DNA replication and Transcription **14 hours**

Introduction to Molecular Biology: Identification of DNA as genetic material-Experimentsof Griffith, Hershey and Chase: Overview of structure of DNA.Chromosomal organization in prokaryotes and Eukaryotes; Gene and gene concept: cistron, muton, recon and replicon. Central dogma of molecular biology and its modification.

Replication: Types of replication; Conservative, semi conservative and dispersive. Evidence for semi conservative replication- Meselson and Stahl experiment. Mechanism of semi conservative replication- Steps involved in replication, enzymes and proteins involved in replication. Properties of DNA polymerase I.
Outline of DNA replication in eukaryotes.

Transcription in prokaryotes: RNA polymerase, mechanism of initiation, organization of promoters and enhancers. Role of sigma factor. Termination (Rho -dependent and independent). Reverse transcription.

Overview of eukaryotic transcription: Eukaryotic RNA polymerases. Post transcriptional mRNA processing: capping, splicing and poly adenylation.

UNIT-II **14 hours**

Translation and Regulation of gene expression

Genetic code: Characteristics of genetic code, wobble hypothesis.
Translation: Mechanism of translation - amino acid activation, charging of tRNA, initiation, elongation, and termination; post-translational modification; Inhibition of protein synthesisby antibiotics.

Mutation: Concept of mutation, Mutagens – chemical and physical, Molecular basis of mutation: spontaneous and induced mutations, intercalating agents and UV-radiation. Point mutations - missense, nonsense and frame shift mutations.

Regulation of gene expression: General aspects of regulation, transcriptional regulation-inducible and repressible system. Operon concepts -lactose, tryptophan operons. Brief account of Eukaryotic geneexpression regulation.

UNIT- III **14 hours**

Overview and Nature of Antigen and Antibody
Organs of the immune system: Anatomy and functions of lymphoid tissues. Haematopoiesis. Cellularcomponents of the immune system - granulocytes- neutrophil, eosinophil, basophil and mast cell, Mononuclear cells- Lymphocytes, Monocytes, Macrophages,NK cells and Dendritic cells.

Antigen: Concept of antigenic determinants and immunogens, factors that influenceimmunogenicity, Classes of antigen, Epitopes, Haptens.

Antibody: Molecular Structure - general features, light and heavychains, Hyper variable and constant regions, Different isotypes and subtypes ofimmunoglobulins, Allotypes and idiotypes.

UNIT- IV **14 hours**

Innate and adaptive Immunity

Innate immunity: Anatomical and physiological barriers, Soluble factors, Inflammation-characteristics, initiation ofthe inflammatory response, Chemotaxis, Phagocytosis, Acute inflammatory response, Role of innate immunity.Cytokines, Complement system.

Adaptive immunity
MHC molecules: genes, different classes, structure and function. Antigen processing andpresentation: Endogenous and exogenous pathways.
Humoral Immunity –BCR, B-cell activation and maturation, generation of plasma cells and memory B cells.
Cell-mediated immunity:Structural organization of T cell-receptors, T-cell maturation and differentiation, Proliferation , B cell – T cell interaction, The germinalcenter reactions.

REFERENCES

1. Molecular Biology-David Friefelder, Narosa Publication-house Pvt.Ltd. New Delhi,2020
2. A Textbook of Biochemistry: Molecular and Clinical Aspects, S. Nagini. 2nd edition. Sci Tech Publ., Chennai, 2007
3. Owen, Judith A., Jenni Punt, and Sharon A. Stranford. Kuby immunology. New York: WH Freeman, 2013.
4. Delves, Peter J., Seamus J. Martin, Dennis R. Burton, and Ivan M. Roitt. &Roitt's Essential immunology. Vol. 20. John Wiley & Sons, 2011.

PEDAGOGY: MOOC/DESKWORK/BOOKCHAPTER/PROBLEMSOLVING /ASSIGNMENT

Formative Assessment	
Assessment occasion	**Weightage in marks**
Class test (2Classtests)	**20**
Seminars/Classwork	**10**
Assignment/Open discussion	**10**
Total	**40**

SEMESTER-VI

Course title	Bioenergetics and Metabolism
Course credits	**04**
Total contact hours	**56**
Duration of ESA	**2.5**
Formative assessment marks	**40**
Summative assessment marks	**60**

Course Outcome:

At the endofthecourse thestudentswillbe ableto

- Understand the concepts of metabolism, characteristics of metabolic pathways and strategies used to study these pathways.
  Gain a detailed knowledge of various catabolic and anabolic pathways and its regulation
- Systematically learn the breakdown and synthesis of amino acids andnucleotides in humans and recognize its relevance with respect to nutrition and human diseases
- Acknowledge the role of inhibitors of nucleotide metabolism which are potentially being used as chemotherapeutic drugs
- Comprehendhow theaminoacid andnucleotide metabolismareintegratedwith carbohydrate and lipid metabolism

Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
Aptitude		x		x				x				
Critical thinking		x		x		x				x		
Subject clarity	x	x				x	x					x
Analytical Skill	x				x	x				x		

UNIT-I **14 hours**

Bioenergetics

Laws of thermodynamics, free energy change, equilibrium constant, energy charge, ATP cycle, phosphorylation potential, and phosphorylgroup transfers. Chemical basis of high standard energy of hydrolysis of ATP, Oxidative phosphorylation: Proton gradientgeneration,redoxloop,Q-cycle,Protonpumping.Theelectrontransportchain-

Peter Mitchell's Chemiosmotic hypothesis and Proton motive force. Fo-F1 ATP synthase – structure,and mechanism of ATP synthesis.

UNIT-II **14 hours**

Metabolism

Anabolism and catabolism, compartmentalization of metabolic pathways.

Metabolism of Carbohydrates: Reactions and energetics of glycolysis, entry of fructose, galactose, mannose and lactose into glycolytic pathway. Fates of pyruvate- conversion of pyruvate to lactate, alcohol and acetyl CoA. Cori's cycle.

Reactions and energetics of TCA cycle,amphibolic and integrating roles of TCA cycle. Anaplerotic reactions. Regulatory steps of glycolysis and TCA cycle, Gluconeogenesis and glycogenolysis. Pentose phosphate pathway and its significance.

Unit-III **14 hours**

Metabolism of Lipids

Introduction, hydrolysis of triacylglycerols, transport of fatty acids into mitochondria, β-oxidation of saturated and unsaturated fatty acids, ATP yield from fatty acid oxidation. Biosynthesis of saturated and unsaturated fatty acids. Fatty Acid Synthase complex, Lipogenesis (Denovo synthesis of Fatty acid), Elongation of Fatty acid (Mitochondrial elongation). Biosynthesis of TAG, Phospholipids (Lecithin and Cephalin).Cholesterol metabolism.

Nucleic Acid metabolism: Degradation of nucleic acids, action of nucleases-DNase I and II, RNase and phosphodiesterases. Catabolism of purines and pyrimidines. Salvage pathways. De novo biosynthetic pathways of purine and pyrimidine nucleotides. Conversion of ribonucleotides to deoxyribonucleotides.

UNIT-IV **14 hours**

Metabolism of Amino acids

General mechanism of amino acid metabolism: Deamination- oxidative and non – oxidative deamination, transamination, decarboxylation (biologically important amines) and desulphuration. Catabolism of carbon skeleton of amino acids, glycogenic and ketogenic amino acids. Urea cycle and its significance. Synthesis and catabolism of alanine, serine and cysteine

REFERENCES

1. Principles of Biochemistry, Donald Voet, Judith G Voet, Charlotte W. Pratt, 4th Edition, JohnWiley and Sons Inc, 2012.
2. Lehninger Principles of Biochemistry; DL Nelson and MM Cox (Eds), 6th Edn. Macmillan Publications, 2012.
3. Biochemistry-the chemical reactions of living cells, David E Metzler, 2nd Edition, Elsevier, Academic Press,
4. Fundamentals of Biochemistry, Jain, J. L, S. Chand publication 6th Edition, 2005.
5. Biochemistry, Jeremy M. Berg, John L. Tymoczko, LubertStryer, Freeman and company, 7th Edition, 2010.
6. Harper's Illustrated Biochemistry,Victor W Rodwell,et.al, 31st edition, McGraw-Hill Education Lange, 2018.

PEDAGOGY: MOOC/DESK WORK/BOOK CHAPTER/PROBLEM SOLVING /ASSIGNMENT

Formative Assessment	
Assessment occasion	**Weightage in marks**
Class test (2class test)	**20**
Seminars/class work	**10**
Assignment/open discussion	**10**
Total	**40**

SEMESTER-VI; Practical-VII

Course title	Bioenergetics and Metabolism Practical
Course credits	02
Contact hours	4 Hours/Week
Duration of ESA	04
Formative assessment marks	25
Summative assessment marks	25

CourseOutcome:

- The practical course will enable the students to learn the estimation of blood substances which tell how well the organs/kidneys are functioning, and glucose, which indicates whether there is a normal amount of sugar in the blood. Blood urea nitrogen is a measure of how well the kidneys are working.
- LearningthestructurallevelsofNucleicacids.

Experiments

1. EstimationofBlood glucose
2. Estimation of protein
3. Estimation of inorganic phosphate
4. Assay of Digestive enzyme
5. Estimation of Urea
6. Estimation of Uric acid
7. Estimation of creatinine
8. Estimation of cholesterol
9. Estimation of vitamin C
10. Determination of A/G ratio

II : Report:

Visit to scientific/research institute–Tour report.

OR

Submission of assignment on recent trends in biochemistry

REFERENCES

1. Practical Biochemistry, Geetha Damodaran, Jaypee, 2011.
2. Biochemical Methods,S.Sadasivam,A.Manickam,3rd Edition, New Age International Pvt. Ltd, 2007.
3. An Introduction to Practical Biochemistry,David Plummer,3rdedition, 2017
4. Laboratory Manual in Biochemistry, J.Jayaraman, 2011.

PEDAGOGY: MOOC/DESK WORK/BOOK CHAPTER/PROBLEM SOLVING/ASSIGNMENT

FormativeAssessment	
Assessment occasion	**Weightage in marks**
Record/Viva voce	**10**
Continuous evaluation and class test	**15**
Total	**25**

SEMESTER-VI; Practical - VIII

Coursetitle	**Molecular Biology and Immunology Practical**
Course credits	**02**
Contact hours	**4 h/week**
Duration of ESA	**03 h**
Formative assessment marks	**25**
Summative assessment marks	**25**

CourseOutcome:

The practical course will enable the students to learn

- Identifying blood groups and types
- Competently perform serological diagnosis
- Analyze components of human sera by performing electrophoresis experiments.

CourseOutcomes	1	2	3	4	5	6	7	8	9	10	11	12
Aptitude		x		x								
Critical thinking		x				x						
Subject clarity	x	x				x	x		x	x	x	x
Analytical Skill	x				x	x				x		

EXPERIMENTS

Molecular biology

1. Isolation of DNA from banana/endosperm of coconut/ bacteria / any other source
2. Agarose gel electrophoresis of nucleic acids
3. Isolation of RNA from spinach leaves/any other source
4. DNA Purity check by UV spectrophotometer
5. Isolation of plasmid from E. *coli*
6. DNA analysis by Restriction endonucleases
7. Western blotting

Immunology

1. Hemagglutination inhibition test
2. WIDAL test
3. ELISA test/assay
4. Isolation of antibodies
5. Differential leucocyte count
6. Ouchterlony double diffusion
7. Radial immune diffusion test
8. Agglutination reactions

REFERENCES:

1. A Handbook of Practical and Clinical Immunology, G.P Talwar and S.K Gupta,2017.
2. Practical Immunology , Frank C Hey, Publisher: John Wiley and Sons Ltd, 2000.
3. An Introduction to Practical Biochemistry,DavidPlummer,3rdedition, 2017.
4. Laboratory Manual in Biochemistry, J.Jayaraman, 2011.
5. Molecular Biology: A Laboratory Manual by Ashwani Kumar S.K. Gakhar, Monika Miglani, 2019.
6. Wilson and Walkers Principles and Techniques of Biochemistry and Molecular Biology 8th edn. (Sae) by Hofmann, 1983.
7. Laboratory Manual of Microbiology, Biochemistry and Molecular Biology by J.Saxena, M. Baunthiyal, I. Ravi, 2015.
8. Biochemical methods, S. Sadasivam, A. Manickam, 3rd Edition, New AgeInternational Pvt Ltd, 2007.

PEDAGOGY: MOOC/DESK WORK/BOOK CHAPTER/PROBLEM SOLVING/ASSIGNMENT

Formative Assessment	
Assessment occasion	**Weightage in marks**
Record/viva- voce	**10**
Continuous evaluation and class test	**15**
Total	**25**

B.Sc. V &VI SEMESTERS MODEL QUESTION PAPER
BIOCHEMISTRY

Time:2.5 h Max.marks:60

Note: all sections are compulsory

SECTION – A

1. Answer any FIVE of the following 5x2= 10

a.
b.
c.
d.
e.
f.
g.

SECTION –B

Answer any FOUR of the following; 4x5= 20

2.
3.
4.
5.
6.
7.

SECTION – C

Answer any THREE Questions 3 x 10 = 30

8.
9.
10.
11.
12.

Note*: Section C may include sub questions, a, and b*

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BENGALURU CITY UNIVERSITY

Department of Biochemistry, Central College Campus, Bangalore -560001

Proceedings of the Meeting of Board of Studies in Biochemistry (UG), held on Thursday the 17th August, 2023 in the chambers of the Chairman, Dept. of Biochemistry, Central College Campus, Bangalore -560001

The meeting scheduled to discuss the V and VI semester B.Sc. Biochemistry course started with the Chairman welcoming the members. The Chairman placed before the board, draft syllabus for V and VI semester B.Sc. Biochemistry proposed by the syllabus committee constituted by the Karnataka State Higher Education Council and guidelines for preparing two major scheme. The proposed syllabus and scheme was discussed in length and the board approved the syllabus conforming to two major patterns. The meeting concluded with the chairman thanking the members for their valuable inputs and cooperation.

Members Present		Signature
1. Prof. V. R. Devaraj, Chairman, Dept. of Biochemistry, Bangalore University.	Chairman	
2 Dr. S. Kantharaju Dept. of Chemistry, SJRC College, Ananda Rao Circle Bangalore -560004	Member	Absent
3. Ms. Vidya, A.S. Dept. of Biochemistry, Seshadripuram College Yalahanka Bangalore -560064.	Member	
4. Dr. (Mrs.) Myrene D'souza Dept. of Biochemistry, Mount Carmel College # 58, Palace Road, Bangalore – 560052	Member	

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5. Dr. R. Nagesh Babu, Member
Dept. of Chemistry,
Maharani's Science College for women,
Palace Road, Bangalore-560001

6. Ms. Malini M.R Member
Dept. of Chemistry,
M.S Ramaiah College of Arts, Science & Commerce
Bangalore-54

7. Dr. Rajeev Ramachandra Kolagi Member
Dept. of Biochemistry,
Nrupathunga University
Bengaluru-560001.

8. Dr. Kamala, A. Member
Dept. of Biochemistry,
MLA College for women
Malleswaram 18th Cross
Bangalore-560004

9. Mrs. Ramya Kumari B.S Member
Dept. of Biochemistry
M.S Ramaiah College of Arts, Science & Commerce
Bangalore-54

10. Mrs. Madhukala. Member
Dept. of biochemistry
Acharya B School,
Magadi Road,
Bengaluru-560091

11. Dr. Bhagyalakshmi Member
Dept. of biochemistry
University College of Science
Tumkur University
Tumkur-572101

12. Mrs. Savitha. K.R. Member
Dept. of biochemistry
University College of Science
Tumkur University
Tumkur-572101