

SEMESTER III

COURSE TITLE	BIO-ORGANIC CHEMISTRY
COURSE CREDITS	04
TOTAL CONTACT HOURS	56
DURATION OF ESA	03
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

14 hours

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

Hydrocarbons -Mechanism of addition of HCl to propene, Markownikoff's rule. 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. Conformational analysis of ethane and n-butane.

UNIT 2: Mechanism of substitution, elimination, and addition reactions

14 hours

S_N1 and S_N2 reactions on tetrahedral carbon, energy profile diagrams, Stereochemistry, factors affecting S_N2 and S_N1 reactions

The Elimination reactions- E₂ reaction, Zaitsev rule, E₁ reaction. Stereochemistry of E₁ & E₂ reactions, E₂ & E₁ elimination from cyclic compounds. Substitution and Elimination reactions in Synthesis.

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

UNIT 3: Mechanism of electrophilic aromatic substitution reactions

14 hours

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. Friedel crafts acylation-mechanism involved. Relative reactivity of substituted benzenes, polycyclic benzenoid hydrocarbons.

The reaction of the coenzymes.

Overall view of metabolism, thiamine pyrophosphate- structure and its role in decarboxylation of alpha- keto acids.

Biotin- structure and its role in carboxylation of some important biochemical reactions of carbohydrate and lipid metabolism.

Vit B₂ its role in rearrangement reactions.

Vit B₂ coenzymes its role in redox reactions with suitable examples.

UNIT 4: Bio-organic compounds

14 hours

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 and properties: Lactic acid, Citric acid and Isocitric acid. Dicarboxylic acids: Maleic and Fumaric acid. Ketoacids: Pyruvic, α -Ketoglutaric, Oxaloacetic acid.

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.

Amines: Classification, properties, functional group – Basicity of amines, acylation. Reaction with HNO₂ & 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, quinoline and isoquinoline. 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. Textbook 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, ed. M. Moloney, Blackwell Science 2000.

PEDAGOGY: MOOC/DESK WORK/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
PRACTICALS III

COURSE TITLE	BIO-ORGANIC CHEMISTRY
COURSE CREDITS	02
TOTAL CONTACT HOURS	4 Hours/Week
DURATION OF ESA	03
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 compounds (6 practicals)

- | | | |
|-------------------|-----------------|-----------------|
| 1. Urea | 2. Aniline | 3. Benzoic Acid |
| 4. Salicylic acid | 5. Benzaldehyde | 6. Acetophenone |
| 7. Chlorobenzene | 8. Nitrobenzene | |

II. Preparation of following organic compounds (2 practicals)

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. Chhikara 2009
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/DESK WORK/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
DURATION OF ESA	03
FORMATIVE ASSESSMENT MARKS	40
SUMMATIVE ASSESSMENT MARKS	60

Course outcome:

These topics will enable students to develop competence in handling various chromatographic, electrophoretic and isotopic techniques and apply them in isolating and characterizing different biological molecules.

UNIT 1 : **14 hours**

Microscopy: Different types of microscopes – electron microscopes – TEM, SEM. Fluorescence and confocal microscopes used in fine structure studies.

Centrifugation Techniques: Introduction, basic principles, and applications of sedimentation. Centrifuges and their use - small bench centrifuges, large capacity refrigerated centrifuges, high speed refrigerated centrifuges, continuous flow centrifuges, Preparative ultra-centrifuges, analytical ultracentrifuges, and density gradient centrifugation.

UNIT 2 : **14 hours**

Chromatography: Introduction, classification of chromatographic techniques. Principle, materials, theory and applications of paper chromatography, thin layer chromatography, column chromatography- adsorption chromatography, gel permeation, ion exchange chromatography, affinity chromatography, gas chromatography, FPLC, high performance (pressure) liquid chromatography.

Electrophoresis techniques: Introduction. Principles and application of electrophoretic techniques-paper electrophoresis, starch gel electrophoresis, polyacrylamide gel electrophoresis, agarose gel electrophoresis, isoelectric focusing, isotachopheresis, pulse field electrophoresis, two-dimensional electrophoresis, capillary electrophoresis, preparative and high voltage electrophoresis.

UNIT 3 :**14 hours**

Radio isotopic techniques: Introduction to isotopes; mass and radioisotopes. Nature of radioactive decay, rate of radioactive decay, units of radioactivity, measurement of radioactivity- proportional counters, scintillation counters, autoradiography, isotopic dilution technique. Applications of radioisotopes in the biological sciences.

Spectroscopy: Introduction, Nature of electromagnetic Radiations. Principles and applications of the following spectroscopic techniques in biochemical investigations- Visible and Ultraviolet spectroscopy, Fluorescence spectroscopy, Infrared spectroscopy, Optical rotation dispersion (ORD), Circular dichroism (CD) spectroscopy, electron spin resonance (ESR), Atomic Absorption spectroscopy, 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, J. Weyers, and 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/DESK WORK/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 ESA	03
FORMATIVE ASSESSMENT MARKS	40
SUMMATIVE ASSESSMENT MARKS	60

Course outcome: These topics will enable the students to:

- 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 :

14 hours

Introduction to the system and concepts of signaling. Classification, intercellular communication, regulation of synthesis and secretion of hormones. Chemical signaling- endocrine, paracrine, autocrine, and neuroendocrine mechanisms. Mechanisms of hormone action: synergism, antagonism, permissive effects. Division of hormones by the origin, chemical structure, location, and mechanism of action. Physiological role and disorders of Pituitary, Pineal, Thyroid and Parathyroid hormones. Introduction to the hypothalamus as the true master gland with Releasing hormones and inhibitory substances. Neurohypophysis and its secretions – ADH and Oxytocin

UNIT 2 :

14 hours

Physiological role and disorders of hormones 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

Ca²⁺). Overview on signal transduction pathways for steroidal and non-steroidal hormones (One example each).

UNIT 3 :

14 hours

Clinical endocrinology- Blood volume, composition and functions of plasma and serum. Separation and storage of body fluids. Methods of hormone estimation, principles of 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. J N Singh (2017), Biochemistry General, Hormonal and Clinical - 1st Edition, Atithi books Publishers.
9. Rifai N (2017), Teitz Textbook of Clinical Chemistry and Molecular Diagnostics, 6th Edition Saunders Publications.

PEDAGOGY: MOOC/DESK WORK/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

COURSE TITLE	ANALYTICAL BIOCHEMISTRY
COURSE CREDITS	04
TOTAL CONTACT HOURS	56
DURATION OF ESA	03
FORMATIVE ASSESSMENT MARKS	40
SUMMATIVE ASSESSMENT MARKS	60

Course outcome: These topics will enable the students to

- Understand the concept of biological sample preparation
- Appreciate chemistry and application of analytical instruments.
- Get acquainted with care and maintenance of equipment and chemicals.
- Understand clinically relevant biochemical analysis of all biochemical components i.e., proteins, electrolytes, hormones etc.,
- Have 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

14 hours

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

Centrifugation- Introduction, principles of centrifugation, Sedimentation, angular velocity, centrifugal field, relative centrifugal field. Types of centrifugations- 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. Sedimentation coefficient, care, and maintenance of instrument.

UNIT 2: Chromatography

14 hours

General principles of chromatography, history of chromatography. Classification based on 1. physical way stationary and mobile phase are brought together- Planar and column chromatography, 2. 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 values.

Classification of chromatography based on separation: Principles, methodologies and applications of adsorption, partition, ion-exchange, gel-filtration and affinity-chromatography. Advanced chromatography- HPLC and FPLC, UPLC and GLC.

UNIT 3: Electrophoretic and radio isotopic methods

14 hours

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, agarose, polyacrylamide. 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 biological activities. Agarose gel and Pulse field electrophoresis, Applications of capillary electrophoresis and isoelectric focusing. Cellulose acetate electrophoresis. Principle and applications of immune-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 – ^3H , ^{14}C , ^{131}I , ^{60}Co and ^{32}P . Biological effects of radiations. Radiolabeling, safety measure in handling radio isotopes.

UNIT 4: Spectroscopic methods of bio-analysis

14 hours

Spectroscopic methods: Wave particle duality of light, electromagnetic spectrum, transition in spectroscopy. Principle, design and application of UV-Vis spectrophotometer. Beer's law and its limitations, determination of molar absorption coefficient of molecules. Working principle and application of a colorimeter, flame photometer and fluorimeter. Principle and application of IR, and Raman, ESR and NMR 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, 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/DESK WORK/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
PRACTICALS IV

COURSE TITLE	ANALYTICAL BIOCHEMISTRY
COURSE CREDITS	02
TOTAL CONTACT HOURS	4 Hours/ Week
DURATION OF ESA	03
FORMATIVE ASSESSMENT MARKS	25
SUMMATIVE ASSESSMENT MARKS	25

Course outcome: This course aims 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. Preparation of human lymphocytes using clinical centrifuge
2. Determination of packed cell volume/ hematocrit
3. Resolution of basic, acidic and aromatic amino acids by descending and circular paper chromatography.
4. Separation of plant pigments by gel-permeation chromatography
5. Identification and resolution of pigments by thin layer chromatography.
6. Determination of void volume of a gel-filtration column
7. Recording the absorption spectrum of riboflavin
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/DESK WORK/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 IV

OPEN ELECTIVE 1

BIOCHEMICAL TOXICOLOGY

COURSE TITLE	BIOCHEMICAL TOXICOLOGY
COURSE CREDITS	03
TOTAL CONTACT HOURS	42
DURATION OF ESA	03
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
- Explain environmental and physiological factors that affect toxicant metabolism

UNIT 1 : Fundamentals of toxicology and dose response

14 hours

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, ED₅₀, LD₅₀/TD₅₀. Hazard and risk assessment, risk, acceptable daily intake (ADI) and tolerable daily intake (TDI).

UNIT 2 : Factors affecting toxic responses

14 hours

Disposition- Outline of toxin/drug uptake, entry to cells and systemic circulation. Effect of size, shape, solubility, and charge on their uptake. Major sites of absorption, liver, intestine, skin, role of transporters, role of plasma proteins in distribution, plasma levels of toxins/drugs, plasma half-life, excretion- disposition by kidney, biliary excretion. Metabolism- types of metabolic changes of foreign compounds, biotransformation/detoxification reactions, phase-1 and, phase -2 reactions, nature of phase-1 and phase 2 enzymes.

UNIT 3 : Targets of toxic damages and biochemical mechanism of toxicity 14 hours

Toxins/drugs causing liver, kidney, gall bladder, and lung damage, methods of identifying the damages.

Examples of biochemical toxicity mechanisms; 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/DESK WORK/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
DURATION OF ESA	03
FORMATIVE ASSESSMENT MARKS	40
SUMMATIVE ASSESSMENT MARKS	60

Course outcomes: These topics will enable the students to

- 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 hours

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 pumps operate at 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: Cellulose, starch, sucrose, oligosaccharides; fructans, gums, mucilages, poly unsaturated fatty acids, lignin, suberin, surface waxes, sulfides and sweet proteins.

UNIT 2 :

14 hours

Plant growth regulators: Auxins, cytokinins, gibberellins, abscisic acid, ethylene, brassinosteroids, polyamines, jasmonic acid, salicylic acid.

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

Plant abiotic stress responses: 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 hours

Plant secondary metabolites (Natural products):

Introduction; secondary metabolites (natural products) definition; classification of plant secondary metabolites (natural products). An overview of primary metabolism contribution to secondary metabolites biosynthesis.

Alkaloids: Classification of alkaloids; Contribution of amino acids for alkaloid biosynthesis; Isolation, purification and characterization of alkaloids. (S)-Seticuline-the chemical chameleon.

Phenolics: Classification of phenolic compounds; Classification of flavonoids; Classification of anthocyanins; Isolation, purification and characterization of phenolics.

Terpenoids: Classification of terpenoids, biogenic isoprene rule; volatile compounds; plant growth regulator terpenoids – gibberellin, abscisic acid; brassinosteroids and saponins Isolation, purification, and characterization of terpenoids

Biological properties of secondary metabolites: Role 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, Grussem and Jones. American Society of Plant Physiologists. 2000
7. Natural Products from plants. Peter B. Kaufman, Leland J. Cseke, Sara Warber, James A. Duke, Harry L. Briemann, 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. Misaka T. 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/DESK WORK/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: 3 h

MAX. MARKS: 60

NOTE: ALL SECTIONS ARE COMPULSORY

SECTION A

1. Answer any FIVE of the following

5 x 2 = 10

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

SECTION B

Answer any FOUR of the following

4 x 5 = 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, b*

BSc III & IV SEMESTERS
MODEL QUESTION PAPER
BIOCHEMISTRY
OPEN ELECTIVE

TIME: 3 h

MAX. MARKS: 60

NOTE: ALL SECTIONS ARE COMPULSORY

SECTION A

1. Answer any FIVE of the following 5 x 2 = 10
- a.
 - b.
 - c.
 - d.
 - e.
 - f.
 - g.

SECTION B

Answer any FOUR of the following 4 x 5 = 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, 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 /Class work - 10	Seminars /Class work – 10	Record / Viva - 10
Assignment /Open discussion - 10	Assignment /Open discussion - 10	