BENGALURU CITY UNIVERSITY

CHOICE BASED CREDIT SYSTEM

(Semester Scheme with Multiple Entry and Exit Options for Under Graduate Course- as per NEP 2020)

Syllabus for Biochemistry
(III & IV Semester)

2022-23 onwards

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BENGALURU CITY UNIVERSITY
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 Malini M.R 3/9/2022

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

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

Dr. V.R. DEVARAJ, M.D.
Chairman
Dept. of Biochemistry
Bangalore City University
Bangalore - 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.

CourseOutcomes/Program Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
Aptitude	X	X	X	X								
Criticalthinking		X										
Subjectclarity	X	X				X	X	X		X		X
AnalyticalSkill	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 andheterolyticcleavage.Conceptofinductiveeffect,mesomericeffect,resonanceandhyperconjugation.Classificationoforganicreactions(substitution,addition,eliminationandre-arrangement), with two examples for each. Concepts reactive intermediates of the following –free radicals, carbocations and carbanions, carbenes, nucleophiles and electrophiles(Formationand Stability).

Hydrocarbons - Markownikoff's rule. Mechanism of addition of HCl to propene. Peroxide effect,Alkenes–Ozonolysis,oxidation.Alkynes–
formationofacetylidesandtheirimportance.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. Additionof ammonia, primary amines and other ammonia derivatives. Conjugate addition - additionin alphaand betaunsaturatedaldehydesandketones, 1,2and 1,4addition.

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-aromaticcompoundswithexamples.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 anduses.

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 organicchemistry andbasic Qualitative analysis of organic compounds. Course Objective is to provide experimentalpracticeofpreparationoforganiccompoundsandextractionofbiologicallyimportantcompounds.

Experiments:

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

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

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

1. Acetylation: Preparationofacetylsalicylic acidfromsalicylicacid.
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

CourseOutcome:

- 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**

CourseOutcome:

- 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: Signalling **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**

Physiologicalrole 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**

CourseOutcome:

- 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								
Criticalthinking		X				X						
Subjectclarity	X	X						X				X
AnalyticalSkill				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 stationaryandmobilephase-Planarandcolumnchromatography, 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 theapplied 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,
- Electrophoresisand
- 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 aboutbiochemical basis of various effects of toxins/ pharmaceuticals and an outline of processinvolved in toxicitytestingand drugdosing.

- Categorizetheclassesof toxicants/drugsandknowspecificexamples
- Statethe routesofexposureto toxins/drugs;
- Explaintheprocessesof absorption,metabolismandeliminationoftoxins/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 primarymetabolites.
- Illustrateplantgrowthregulators,plant's responsestovariousbioticandabioticstresses.
- Explainaboutplant secondarymetabolites andtheir functionalimportance.

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; Differenttypes of transportersin 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.
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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)
ClassTest -20	ClassTest -20	Continuousevaluation&class test -15
Seminars/Classwork-10	Seminars/Classwork –10	Record/Viva-10
Assignment/Opendiscussion-10	Assignment/Opendiscussion-10	