**Kurukshetra University Kurukshetra**

**Scheme of Examination and Syllabus for B.Sc. (Medical)**

**Under**

**Choice Based Credit System (CBCS)**

**W.e.f. 2020-21 (in phased manner)**

**Subject: Biochemistry**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Semester** | **Course** | **Paper** | **Nomenclature of paper** | **Work load Hrs/Week** | **Credits** | **Internal marks** | **External Marks** | **Total** | **Duration of Exam.(Hrs)** |
| 1 | CC-1 | B-BCH-101 | Molecules of life-I | 3 | 3 | 15 | 60 | 75 | 3 |
| B-BCH-102 | Molecules of life-II | 3 | 3 | 15 | 60 | 75 | 3 |
| B-BCH-103 | Molecules of life- Practicals | 4 | 2 | 10 | 40 | 50 | 3 |
| 2 | CC-2 | B-BCH-201 | Enzymes-I | 3 | 3 | 15 | 60 | 75 | 3 |
| B-BCH-202 | Enzymes-II | 3 | 3 | 15 | 60 | 75 | 3 |
| B-BCH-203 | Enzymes-practicals | 4 | 2 | 10 | 40 | 50 | 3 |
| 3 | CC-3 | B-BCH-301 | Metabolism-I | 3 | 3 | 15 | 60 | 75 | 3 |
| B-BCH-302 | Metabolism-II | 3 | 3 | 15 | 60 | 75 | 3 |
| B-BCH-303 | Metabolism-practicals | 4 | 2 | 10 | 40 | 50 | 3 |
| 4 | CC-4 | B-BCH-401  | Molecular Biology-I  | 3 | 3 | 15 | 60 | 75 | 3 |
| B-BCH-402 | Molecular Biology-II  | 3 | 3 | 15 | 60 | 75 | 3 |
| B-BCH-403 | Molecular Biology-practicals | 4 | 2 | 10 | 40 | 50 | 3 |
| SEC- 1 | B-BCH –S1 | Tools and Techniques in Biochemistry | 2 | 2 | 10 | 40 | 50 | 3 |
| 5 | DSE- 1 | B-BCH-501 | Immunology-I  | 2 | 2 | 10 | 40 | 50 | 3 |
| B-BCH-502 | Immunology-II | 2 | 2 | 10 | 40 | 50 | 3 |
| B-BCH-503 | Immunology-Practicals | 4 | 2 | 10 | 40 | 50 | 3 |
| OR |  |
| B-BCH-504 | Plant Biochemistry-I | 2 | 2 | 10 | 40 | 50 | 3 |
| B-BCH-505 | Plant Biochemistry-II | 2 | 2 | 10 | 40 | 50 | 3 |
| B-BCH-506 | Plant Biochemistry-Practicals | 4 | 2 | 10 | 40 | 50 | 3 |
| B-BCH-507 | MOOC\* (From Swayam Portal) |  | \* |  |  | \* |  |
| 6 | DSE-2 | B-BCH-601 | Clinical Biochemistry-I | 2 | 2 | 10 | 40 | 50 | 3 |
| B-BCH-602 | Clinical Biochemistry-II | 2 | 2 | 10 | 40 | 50 | 3 |
| B-BCH-603 | Clinical Biochemistry-Practicals | 4 | 2 | 10 | 40 | 50 | 3 |
| OR |  |
| B-BCH-604 | Nutritional Biochemistry-I | 2 | 2 | 10 | 40 | 50 | 3 |
| B-BCH-605 | Nutritional Biochemistry-II | 2 | 2 | 10 | 40 | 50 | 3 |
| B-BCH-606 | Nutritional Biochemistry-Practicals | 4 | 2 | 10 | 40 | 50 | 3 |

**Note**- SEC can be offered in 4th, 5th or 6th semester depending upon the time table adjustments in the institute/college

**Programme Outcomes (POs) for UG courses of Faculty of Life Sciences**

1. To develop skills in graduate students to be able to acquire theoretical and practical knowledge in fundamentals of biology in respective disciplines of plants, animals, microbes and environment.
2. To inculcate ability to critically evaluate problems and apply lateral thinking and analytical skills for professional development.
3. To create awareness on ethical issues, good laboratory practices and biosafety.
4. To develop ability in youth for understanding basic scientific learning and effective communication skills.
5. To prepare youth for career in teaching, industry, government organizations and self reliant entrepreneurship.
6. To make students aware of natural resources and environment and its sustainable utilization.
7. To provide learning experience in students that instills deep interest in biological science for the benefit of society.

**Programme Specific Outcomes (PSOs) for UG course with Biochemistry**

After the successful completion of the course the student will be able to

1. **PSO1-** To demonstrate the knowledge and understanding of biochemistry, structure and function of biological molecules, biological mechanisms, such as the processes and control of bioenergetics and metabolism, as chemical reactions.
2. **PSO2-** critically think and correlate the biochemical knowledge day to day routine to improve quality of life in person & community in general.
3. **PSO3-** Demonstrate the understanding of the principles of biochemical techniques and exhibit basic professional skills pertaining to biochemical analysis carry out laboratory-orientated numerical calculations and analyze biochemical data (e.g. in enzyme kinetics, molecular structure analysis, clinical analysis, immunological inferences).
4. **PSO4-** Demonstrate the scientific writing and authentic reporting, effective presentation skills and ability to work in a group in collaboration and with cooperation.

**Semester – I**

**CC-BIOCHEMISTRY-1**

**Paper: B-BCH-101**

**Molecules of Life-I**

**Credits: 3**

**Total Marks: 75**

**External Marks: 60**

**Internal Assessment: 15**

**Examination Time: 3 h**

**Learning Outcomes**: After the successful completion of the course the student will be able to

101.1 Describe the basic chemistry and properties of water; physiological buffers; Classify, define and explain various properties of carbohydrates and correlate them to their functions.

101.2 Classify, define, draw structures and explain functions of various types of lipids: Illustrate various parameters of characterization of lipids.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each section. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each section. All questions carry equal marks.

## SECTION -A

### Water and Buffers: Structure, hydrogen bonding, solvent properties, and ionization, Fitness of the aqueous environment for living organisms, Weak acids and bases,ionization of weak acids, titration of weak acid by a strong base, pH, buffers, Henderson-Hasselbalch equation and physiological buffers; phosphate, bicarbonate, amino acid, protein, hemoglobin buffer system

### Carbohydrates: Definition and classification. Monosaccharides: Structure, occurrence and biological importance of common monosaccharides; Stereoisomerism of sugars; Killani cyanohydrins synthesis, Mutarotation; Reactions: oxidation, reduction, periodic acid oxidation, reactions with hydrazine, hydroxylamine, action of acids & alkalies, formation of glycosides and esters. Important derivatives of monosaccharides: deoxy sugars and amino sugars. Structure, occurrence and functions of important di- and trisaccharides. Polysaccharides: Structure, occurrence and biological importance of starch, glycogen, cellulose, chitin, pectins, glycosaminoglycans & proteoglycans.

## SECTION – B

### Lipids: Definition and classification. Fatty acids: introduction, classification, nomenclature, structure and properties of saturated and unsaturated fatty acids. Essential fatty acids. Waxes, Triacylglycerols: physical and chemical properties. Characterization of fats: Saponification values, iodine value, rancidity of fats, Reichert-Meissel number, peroxide value. Reactions of glycerol. Biological significance of fats. Structure & biological functions of glycerophospholipids (lecithin, cephalin, phosphatidylserine, phosphatidylinositol, plasmalogens), sphingolipids and glycolipids (cerebrosides and gangliosides), Structure & biological functions of steroids (cholesterol, ergosterol, lanosterol, bile acids. Structure, properties and functions of isoprenoids (β-carotene, α-carotene) and prostaglandins.

###### **Suggested reading**

1. Lehninger: Principles of Biochemistry, 7th edition, by David L. Nelson and M.M. Cox (2017) Maxmillan/ Worth publishers.
2. Fundamentals of Biochemistry: Life at the Molecular Level, 5th Edition, by Donald Voet, Judith G Voet, Charlotte W. Pratt (2016). John Wiley & Sons, NY
3. Biochemistry, 4th edition, by R.H. Garrett and C.M. Grisham (2010). Saunders College Publishing, NY.
4. Outlines of Biochemistry by E.E.Conn, P.K.Stumpf, G. Bruenimg and Ray H.Doi (1987), John Wiley
5. Biochemistry, 5th edition, by Laurence A. Moran, H. R. Horton, K.G. Scrimgeour, Marc D. Perry (2011), Pearson Publishers.
6. Fundamental of Biochemistry by J.L. Jain, Sanjay Jain, Nitin Jain, S. Chand & Co. Publication.

 **Semester – I**

**CC-BIOCHEMISTRY-1**

**Paper: B-BCH-102**

**Molecules of Life-II**

**Credits: 3**

**Total Marks: 75**

**External Marks: 60**

**Internal Assessment: 15**

**Examination Time: 3 h**

**Learning Outcomes**: On successful completion of the course the student will be able to

102.1Classify, draw structures of standard amino acids, explain chemical and physical properties of amino acids; Describe different classes of proteins and explain different levels of structural organization in protein architecture.

102.2 Explain the characteristics and draw structures of various types of nucleic acids; Illustrate chemical and physical properties, structures and biological functions of porphyrins.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each section. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each section. All questions carry equal marks.

## SECTION – A

### Proteins: Introduction, classification based on solubility, shape, composition and functions. Amino acids: common structural features, stereoisomerism and RS system of designating optical isomers, classification and structures of standard amino acids as Zwitter ion in aqueous solutions, physical and chemical properties, titration of amino acids, essential amino acids and non protein amino acids. Peptides: structure of peptide bond, Merrifield solid-phase synthesis of polypeptides. Determination of the amino acid sequence of a polypeptide chain. Biological functions of polypeptides, Protein structure: levels of structure in protein architecture (Primary, secondary, tertiary and quaternary structures of proteins), Ramachandran plot and forces stabilizing these structures. Denaturation and renaturation of proteins. Salting-in and salting-out of proteins.

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## SECTION – B

Nucleic acids: Structures of purines pyrimidines, nucleosides and nucleotides in RNA and DNA, generalized structural plan of nucleic acids, nomenclature used in writing structure of nucleic acids, features of DNA double helix and forces stabilizing DNA double helix. A, B and Z-DNAs. Chargaffs rules. Denaturation (Tm and buoyant density and their relationship with G-C content in DNA) and annealing of DNA. Structure and roles of different types of RNA. Central dogma of molecular biology.

Porphyrins: Porphyrin nucleus and classification of porphyrins. Important metalloporphyrins occurring in nature. Bile pigments- chemical nature and their physiological significance.

###### **Suggested reading**

1. Lehninger: Principles of Biochemistry, 7th edition, by David L. Nelson and M.M. Cox (2017) Maxmillan/ Worth publishers.
2. Fundamentals of Biochemistry: Life at the Molecular Level, 5th Edition, by Donald Voet, Judith G Voet, Charlotte W. Pratt (2016). John Wiley & Sons, NY
3. Biochemistry, 4th edition, by R.H. Garrett and C.M. Grisham (2010). Saunders College Publishing, NY.
4. Biochemistry, 8th edition, by J.M. Berg, John L. Tymoczko, L. Stryer (2015). W.H. Freeman & Co.,NY.
5. Outlines of Biochemistry by E.E.Conn, P.K.Stumpf, G. Bruenimg and Ray H.Doi (1987), John Wiley
6. Harpers Illustrated Biochemistry, 31st edition, Peter J. Kennelly, P. Anthony Weil, Victor W Rodwell, David A. Bender, Kathleen M. Botham (2018) McGraw Hill Educations Publishers.
7. Biochemistry, 5th edition, by Laurence A. Moran, H. R. Horton, K.G. Scrimgeour, Marc D. Perry (2011), Pearson Publishers.

**Semester – I**

**CC-BIOCHEMISTRY-1**

**Paper: B-BCH- 103**

**Molecules of Life - Practicals**

 **Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes**: On successful completion of the course the student will be able to

103.1 Prepare various types of solutions used in qualitative and quantitative biochemical estimations; verify and apply the basic principles of spectroscopy

## 103.2 Analyse the unknown samples qualitatively for the presence of various biomolecules

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Preparation of normal, molar, percent solutions, buffer solutions and determination of their pH.
2. Qualitative tests for Carbohydrates
3. Qualitative tests for lipids
4. Qualitative tests for amino acids and Proteins
5. Estimation of acid value and saponification value of fat sample
6. Verification of Beer- Lambert’s Law.

### Suggested reading

1. An introduction to Practical Biochemistry, 3rd Edition, by David Plummer (2017). Tata Mc-Graw Hill
2. Introductory Practical Biochemistry by S.K.Sawhney & R. Singh (2014). Narosa Publishers
3. Modern Experimental Biochemistry, 3rd edition, by R. Boyer (2002) Addison-Wesley Longman.
4. Biochemical Methods by Sadasivam & Manickam (1996) New Age International (P) Ltd.
5. A Lab. Manual in Biochemistry by J. Jayaraman (1996) New Age International (P) Ltd.

**Semester – II**

**CC-BIOCHEMISTRY-2**

**Paper: B-BCH- 201**

**ENZYMES-I**

**Credits: 3**

**Total Marks: 75**

**External Marks: 60**

**Internal Assessment: 15**

**Examination Time: 3 h**

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**Outcomes:** After successful completion students will be able to

201.1 Define various characteristics of enzymes, classify them and elaborate the role of cofactors in enzyme catalysis

201.2 Correlate the structure of enzymes to their functions, mechanism of enzyme catalysis and describe various approaches for purification of enzymes

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

 Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each section. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each section. All questions carry equal marks.

**SECTION - A**

Enzymes: Historical perspectives, general characteristics, nomenclature & classification, significance of numbering system, holoenzyme, apoenzyme, coenzymes, cofactors, activators, inhibitors, active site, metallo-enzymes, isoenzymes, monomeric enzymes, oligomeric enzymes, multifunctional enzyme and multi-enzyme complexes. Enzyme specificity (absolute, group and optical specificity), Three point attachment theory of enzyme specificity, Measurement and expression of enzyme activity: Enzyme assay, enzyme units, enzyme turn over number and specific activity.

Role of cofactors in enzyme catalysis: NAD/NADP, FMN/FAD, coenzyme A, biocytin, Vitamin B12 Coenzyme, lipoamide, TPP, pyridoxal phosphate, tetrahydrofolate and metal ions with special emphasis on coenzyme functions.

**SECTION - B**

Enzyme catalysis: Reaction co-ordinate diagram, transition state, Acid-base catalysis, covalent catalysis, proximity and orientation effects, strain and distortion theory. Mechanism of action of chymotrypsin, carboxypeptidase,and ribonuclease.

Enzyme Purification: Methods of isolation of enzymes, purification of enzymes - ammonium sulfate precipitation, molecular-sieving, ,ion-exchange chromatography, affinity chromatography, criteria of homogeneity and determination of molecular weight of enzyme.

###### **Suggested reading**

1. Structure and mechanism in Protein Science, by Alan Fersht (2017). World Scientific
2. Fundamentals of Enzymology, 3rd edition, by Nicholas C. Price and Lewis Stevens (2009) Oxford U.
3. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry by Trevor Palmer, Philip Bonner (2008) East West Publishing.
4. The Chemical Kinetics of Enzyme action by K.J. Laidler and P.S. Bunting, Oxford University Press London.

 **Semester – II**

**CC-BIOCHEMISTRY-2**

**Paper: B-BCH- 202**

**ENZYMES-II**

**Credits: 3**

**Total Marks: 75**

**External Marks: 60**

**Internal Assessment: 15**

**Examination Time: 3 h**

**Learning Outcomes:** After successful completion students will be able to

### 202.1 Exhibit the knowledge of enzyme kinetics of unisubstrate reactions, various kinetics parameters (Km, Vmax etc.) and describe different types of enzyme inhibitions.

### 202.2 Correlate different ways of enzyme regulation to cellular metabolism: discuss and analyse the industrial importance of enzymes and the techniques to use them.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

 Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each section. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each section. All questions carry equal marks.

## SECTION-A

### Enzyme Kinetics: Factors affecting enzyme activity- enzyme concentration, substrate concentration, pH and temperature. Derivation of Michaelis - Menten equation for uni-substrate reactions. Km and its significance. Lineweaver-Burk plot. Importance of Kcat/Km. Bi-substrate reactions- brief introduction of sequential and ping-pong mechanisms with examples.

### Reversible (competitive, non-competitive and uncompetitive inhibitions) and irreversible inhibition. Determination of Km & Vmax in the presence and absence of inhibitor.

## SECTION-B

### Enzyme regulation: Feedback inhibition, Allosteric enzymes. Covalently modulated enzymes. Zymogen activation.

**Immobilized enzymes:** Advantages, methods of immobilization - Adsorption, ionic binding, covalent coupling, cross-linking, entrapment, microencapsulation etc. Applications of immobilized enzymes (A brief account). Industrial applications of enzymes (Production of glucose from starch, cellulose and dextran; use of lactase in dairy industry; production of glucose-fructose syrup from sucrose; use of protease in food, detergent and leather industry).

###### **Suggested reading**

1. Structure and mechanism in Protein Science, by Alan Fersht (2017). World Scientific
2. Fundamentals of Enzymology, 3rd edition, by Nicholas C. Price and Lewis Stevens (2009) Oxford U.
3. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry by Trevor Palmer, Philip Bonner (2008) East West Publishing.
4. The Chemical Kinetics of Enzyme action by K.J. Laidler and P.S. Bunting, Oxford University Press London.

 **Semester – II**

**CC-BIOCHEMISTRY-2**

**Paper: B-BCH- 203**

**Enzymes - Practicals**

 **Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** After successful completion students will be able to

203.1 Extract and quantitatively estimate the enzyme activity and protein content of the samples

203.2 Exhibit skills in studying various characteristics of enzymes like pH optima, temperature optima, Km, Vmax

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Estimation of protein by biuret / Lowry method
2. Assay of acid phosphatase activity from germinating mungbean seeds and calculation of specific activity of acid phosphatase.
3. Effect of enzyme concentration on enzyme activity.
4. Effect of substrate concentration on acid phosphatase activity and determination of its Km value.
5. Effect of pH on enzyme activity and determination of optimum pH.
6. Effect of Temperature on Enzyme activity.

### Suggested reading:

1. An introduction to Practical Biochemistry, 3rd Edition, by David Plummer (2017). Tata Mc-Graw Hill
2. Introductory Practical Biochemistry by S.K.Sawhney & R. Singh (2014). Narosa Publishers
3. Modern Experimental Biochemistry, 3rd edition, by R. Boyer (2002) Addison-Wesley Longman.
4. Biochemical Methods by Sadasivam & Manickam (1996) New Age International (P) Ltd.
5. A Lab. Manual in Biochemistry by J. Jayaraman (1996) New Age International (P) Ltd.

**Semester – III**

**CC-BIOCHEMISTRY-3**

**Paper: B-BCH- 301**

**Metabolism-I**

**Credits: 3**

**Total Marks: 75**

**External Marks: 60**

**Internal Assessment: 15**

**Examination Time: 3 h**

**Outcomes:** After successful completion students will be able to

* 1. Apply the knowledge of biological redox reactions, coupled reactions, energy rich compounds and the energy transactions in studying metabolism; describe the metabolic pathways *i.e.* glycolysis (catabolism), gluconeogensis (anabolism), and TCA cycle and their regulations
	2. Discuss the reactions, regulation and importance of pentose phosphate pathway, glycogen metabolism, glyoxylate, ETC and apply the concept of oxidative phosphorylation to calculate energy production by oxidation of carbohydrates

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each section. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each section. All questions carry equal marks.

## SECTION –A

**Bioenergetics:** Concept of free energy, standard free energy, relation between equilibrium constant and standard free energy change and coupled reactions. Biological oxidation-reduction: redox potentials, relation between standard reduction potentials and free energy change (derivations and numericals included). High-energy compounds: phosphate group transfer potential, free energy of hydrolysis of ATP, PEP and other sugar phosphates along with reasons for high ΔG.

### Carbohydrate Metabolism: Reactions and energetics of glycolysis. Alcoholic and lactic acid fermentations. Feeder pathways, Entry of fructose, galactose, mannose etc into glycolysis. Reactions and energetics of TCA cycle. Regulation of glycolysis and TCA cycle. Gluconeogenesis.

## SECTION- B

### Carbohydrate-related other metabolic pathways: Glycogenesis and glycogenolysis. Regulation of glycogen metabolism. Reactions and physiological significance of pentose phosphate pathway. Glyoxylate cycle.

### Electron Transport Chain and Oxidative Phosphorylation: Structure of mitochondria, organization and sequence of electron carriers, sites of ATP production, inhibitors of electron transport chain. Oxidative phosphorylation: chemiosmotic theory, structure of ATP synthase, binding change mechanism for proton driven ATP sysnthesis, Inhibitors and uncouplers of oxidative phosphorylation. Transport of reducing equivalents from cytosol into mitochondria.

###### **Suggested reading:**

1. Lehninger: Principles of Biochemistry, 7th edition, by David L. Nelson and M.M. Cox (2017) Maxmillan/ Worth publishers.
2. Fundamentals of Biochemistry: Life at the Molecular Level, 5th Edition, by Donald Voet, Judith G Voet, Charlotte W. Pratt (2016). John Wiley & Sons, NY
3. Biochemistry, 4th edition, by R.H. Garrett and C.M. Grisham (2010). Saunders College Publishing, NY.
4. Outlines of Biochemistry by E.E.Conn, P.K.Stumpf, G. Bruenimg and Ray H.Doi (1987), John Wiley
5. Biochemistry, 5th edition, by Laurence A. Moran, H. R. Horton, K.G. Scrimgeour, Marc D. Perry (2011), Pearson Publishers.

 **Semester – III**

**CC-BIOCHEMISTRY-3**

**Paper: B-BCH- 302**

**Metabolism-II**

**Credits: 3**

**Total Marks: 75**

**External Marks: 60**

**Internal Assessment: 15**

**Examination Time: 3 h**

**Outcomes:** After successful completion students will be able to

* 1. Describe the reactions and regulation of lipid biosynthesis and catabolism by beta, alpha and omega oxidative pathways: ketone bodies metabolism and integration to the metabolism of other biomolecules
	2. Analyse how amino acid catabolism leads to formation of diverse type molecules including ketone bodies, glucose, urea: discuss the catabolism and anabolismof nucleic acids and porphyrins

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each section. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each section. All questions carry equal marks.

## SECTION- A

### Lipid Metabolism: Introduction, hydrolysis of triacylglycerols, activation of fatty acids, transport of fatty acyl CoA into mitochondria, beta-oxidation of saturated, unsaturated and odd chain fatty acids; alpha & omega oxidation of fatty acids. ATP yield from fatty acid oxidation.

### Biosynthesis of saturated fatty acids. Metabolism of ketone bodies. Biosynthesis of triglycerides, phospholipids and sphingolipids.

## SECTION- B

### Amino acid Metabolism: General reactions of amino acid metabolism: transamination, oxidative and non-oxidative deamination and decarboxylation. Urea cycle. Glycogenic and ketogenic amino acids. Biosynthesis of aromatic amino acids. Glucose-Alanine cycle.

### Nucleotide Metabolism: Sources of the atoms in the purine and pyrimidine molecules, *denovo* biosynthesis and degradation of purine and pyrimidine nucleotides, Regulation of purine and pyrimidine biosynthesis. Salvage pathways of purines and pyrimidines.

**Porphyrin Metabolism**: Biosynthesis & degradation of heme.

###### **Suggested reading:**

1. Lehninger: Principles of Biochemistry, 7th edition, by David L. Nelson and M.M. Cox (2017) Maxmillan/ Worth publishers.
2. Fundamentals of Biochemistry: Life at the Molecular Level, 5th Edition, by Donald Voet, Judith G Voet, Charlotte W. Pratt (2016). John Wiley & Sons, NY
3. Biochemistry, 4th edition, by R.H. Garrett and C.M. Grisham (2010). Saunders College Publishing, NY.
4. Outlines of Biochemistry by E.E.Conn, P.K.Stumpf, G. Bruenimg and Ray H.Doi (1987), John Wiley
5. Biochemistry, 5th edition, by Laurence A. Moran, H. R. Horton, K.G. Scrimgeour, Marc D. Perry (2011), Pearson Publishers.

 **Semester – III**

**CC-BIOCHEMISTRY-3**

**Paper: B-BCH- 303**

**Metabolism - Practicals**

 **Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** After successful completion students will be able to

## Determine biomolecules in the samples quantitatively.

* 1. Isolate and characterize carbohydrates, lipids and proteins from the natural sources

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Estimation of nitrogen by micro-Kjeldahl method.

## Estimation of blood glucose by colorimetrically.

1. Estimation of ascorbic acid by titrimetric method.
2. Preparation of starch from potato and determination of achromatic point by salivary amylase
3. Isolation of total lipids by Folch method and determine acid value.
4. Isolation of casein from milk and determination of isoelectric pH.

### Suggested reading:

1. An introduction to Practical Biochemistry, 3rd Edition, by David Plummer (2017). Tata Mc-Graw Hill
2. Introductory Practical Biochemistry by S.K.Sawhney & R. Singh (2014). Narosa Publishers
3. Modern Experimental Biochemistry, 3rd edition, by R. Boyer (2002) Addison-Wesley Longman.
4. Biochemical Methods by Sadasivam & Manickam (1996) New Age International (P) Ltd.
5. A Lab. Manual in Biochemistry by J. Jayaraman (1996) New Age International (P) Ltd.

**Semester – IV**

**CC-BIOCHEMISTRY-4**

**Paper: B-BCH- 401**

**Molecular Biology-I**

**Credits: 3**

**Total Marks: 75**

**External Marks: 60**

**Internal Assessment: 15**

**Examination Time: 3 h**

**Learning Outcomes:** After successful completion students will be able to

401.1 Elaborate the central dogma of life at molecular level and the general principles of gene organization, DNA supercoiling; nucleases and various approaches of sequencing of DNA

401.2 Describe the structure and functions of proteins involved in replication and mechanism of DNA replication and correlate molecular basis of different types of DNA mutations with the repair systems of the mutations

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each section. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each section. All questions carry equal marks.

**SECTION - A**

**Basic Concepts of Genetic Information:** Nucleic acids as genetic information carriers: experimental evidences e.g. bacterial genetic transformation, Hershey-Chase experiment, TMV reconstitution experiment. Central dogma of molecular genetics: current version. Salient features of prokaryotic, eukaryotic and viral genomes. Histons and nucleosomes. Highly repetitive, moderately repetitive and unique DNA sequences, telomeres, SINES, LINES, c-value paradox, satellite DNA.

**DNA Supercoiling:** A brief account of DNA supercoiling and topoisomerases. DNA Sequencing: Sequencing of DNA by chemical cleavage and dideoxy methods. Nucleases: Important DNases and RNases including restriction endonucleases.

**SECTION – B**

**DNA Replication:** DNA replication in prokaryotes-conservative, semiconservative and dispersive types, experimental evidence for semiconservative replication. Enzymes and protein factors involved in replication, mechanism of replication and inhibitors of DNA replication.

**Mutations and DNA Repair:** Mutations: Types of mutations, Physical and chemical mutagens, Molecular basis of mutation and Ames test of carcinogenicity. DNA Repair: UV repair systems in *E. coli*, base-excision repair, nucleotide-excision repair & significance of thymine in DNA.

**Suggested reading:**

1. Lehninger: Principles of Biochemistry, 7th edition, by David L. Nelson and M.M. Cox (2017) Maxmillan/ Worth publishers.
2. Fundamentals of Biochemistry: Life at the Molecular Level, 5th Edition, by Donald Voet, Judith G Voet, Charlotte W. Pratt (2016). John Wiley & Sons, NY
3. Biochemistry, 4th edition, by R.H. Garrett and C.M. Grisham (2010). Saunders College Publishing, NY.
4. Outlines of Biochemistry by E.E.Conn, P.K.Stumpf, G. Bruenimg and Ray H.Doi (1987), John Wiley
5. Biochemistry, 5th edition, by Laurence A. Moran, H. R. Horton, K.G. Scrimgeour, Marc D. Perry (2011), Pearson Publishers.
6. Biochemistry, 8th edition, by J.M. Berg, John L. Tymoczko, L. Stryer (2015). W.H. Freeman & Co.,NY.
7. Molecular Cell Biology, 8th edition, by Harvey Lodish et al. (2016), Macmillian learning
8. Molecular Biology of the Gene, 7th edition, by J.D. Watson (2017), Pearson Publisher.
9. Genes XII by B. Lewin (2017), Jones and Bartlett Publishers

 **Semester – IV**

**CC-BIOCHEMISTRY-4**

**Paper: B-BCH- 402**

**Molecular Biology-II**

**Credits: 3**

**Total Marks: 75**

**External Marks: 60**

**Internal Assessment: 15**

**Examination Time: 3 h**

**Learning Outcomes:** After successful completion students will be able to

* 1. Give an insight of the process of gene expression, mechanism of transcription, post-transcriptional processing of RNA in prokaryotes; Describe and correlate the concept of genetic code and mechanism of translation in prokaryotes
	2. Describe the process of regulation of gene expression in prokaryotes and exhibit the knowledge of basics of recombinant technology for the manipulation of genetic information stored in the cells with the help of diverse cloning vectors

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

 Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each section. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each section. All questions carry equal marks.

**SECTION-A**

**Transcription:** Transcription in prokaryotes: RNA polymerase, promoters, initiation, elongation and termination of RNA synthesis, inhibitors of transcription. Reverse transcriptase and a brief

account of post-transcriptional processing of RNA.

**Translation:** Genetic code- Basic features of genetic code, biological significance of degeneracy, Wobble hypothesis, split genes and overlapping genes. Mechanisms of translation: Ribosome structure; Activation of amino acids; initiation, elongation and termination of translation and Inhibitors of translation.

**SECTION-B**

**Regulation of Gene Expression in prokaryotes:** Enzyme induction and repression, Lac operon.

**Recombinant DNA Technology**: Introduction, steps of gene cloning, cloning vectors: features of an ideal cloning vector; plasmids, phages and cosmids as cloning vectors; ligation of insert DNA with vector; transformation of recombinant into host; selection and screening of recombinants; gene library and cDNA library.

**Suggested reading:**

1. Lehninger: Principles of Biochemistry, 7th edition, by David L. Nelson and M.M. Cox (2017) Maxmillan/ Worth publishers.
2. Fundamentals of Biochemistry: Life at the Molecular Level, 5th Edition, by Donald Voet, Judith G Voet, Charlotte W. Pratt (2016). John Wiley & Sons, NY
3. Biochemistry, 4th edition, by R.H. Garrett and C.M. Grisham (2010). Saunders College Publishing, NY.
4. Outlines of Biochemistry by E.E.Conn, P.K.Stumpf, G. Bruenimg and Ray H.Doi (1987), John Wiley
5. Biochemistry, 5th edition, by Laurence A. Moran, H. R. Horton, K.G. Scrimgeour, Marc D. Perry (2011), Pearson Publishers.
6. Biochemistry, 8th edition, by J.M. Berg, John L. Tymoczko, L. Stryer (2015). W.H. Freeman & Co.,NY.
7. Molecular Cell Biology, 8th edition, by Harvey Lodish et al. (2016), Macmillian learning
8. Molecular Biology of the Gene, 7th edition, by J.D. Watson (2017), Pearson Publisher.
9. Genes XII by B. Lewin (2017), Jones and Bartlett Publishers

 **Semester – IV**

**CC-BIOCHEMISTRY-4**

**Paper: B-BCH- 403**

**Molecular Biology - Practical’s**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** After successful completion students will be able to

* 1. Isolate and quantify genetic material from plant/animal sources by colorimetric methods
	2. Exhibit the skill in separating the fragments of DNA by electrophoresis and characterizing by absorption spectrum.

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practical’s:**

## Isolation of DNA from plant/Animal source

## Estimation of DNA by diphenylamine method.

1. Separation of DNA fragments by Agarose gel electrophoresis
2. Isolation of RNA from spinach leaves/bacteria/yeast

## Estimation of RNA by orcinol method.

## Determination of absorption maxima of nucleic acids

### Suggested reading:

1. An introduction to Practical Biochemistry, 3rd Edition, by David Plummer (2017). Tata Mc-Graw Hill
2. Introductory Practical Biochemistry by S.K.Sawhney & R. Singh (2014). Narosa Publishers
3. Modern Experimental Biochemistry, 3rd edition, by R. Boyer (2002) Addison-Wesley Longman.
4. Biochemical Methods by Sadasivam & Manickam (1996) New Age International (P) Ltd.
5. A Lab. Manual in Biochemistry by J. Jayaraman (1996) New Age International (P) Ltd.

 **Semester – IV**

**SEC-1**

**Paper: B-BCH-S1**

## Tools and Techniques in Biochemistry

**Credits: 2**

**Total Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Examination Time: 3 h**

**Learning Outcomes:** Students who successfully complete this course will be able to

S1.1 Demonstrate the knowledge of the general principles, components and applications of pH meter and centrifuges; principles and applications of chromatographic techniques in isolation, quantification and characterization of biomolecules

S1.2 Demonstrate the knowledge of the general principles, components and applications of spectrophotometer; principles and applications of electrophoresis and radioisotopes in biochemical studies.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each section. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each section. All questions carry equal marks.

**SECTION-A**

**Measurement of pH:** Principles and composition of reference electrodes, glass electrode and combined electrode.

**Hydrodynamic Methods**: Sedimentation: sedimentation velocity including factors affecting it, preparative and analytical centrifugation techniques, ultracentrifugation, determination of molecular weight by hydrodynamic methods (derivations excluded and numericals included).

**Chromatographic techniques**- General principles and applications of adsorption, ion-exchange, molecular-sieve, thin layer, hydrophobic, affinity & paper chromatography.

**SECTION-B**

**Electrophoresis**- Basic principles of electrophoresis; Native & SDS-PAGE; Agarose gel electrophoresis.

**Radioisotopic Techniques**: Types of radiations, radioactive decay, units of radioactivity, detection and measurement of radioactivity (methods based on gas ionization and liquid scintillation counting) and Quenching. Biological hazards of radiations and safety measures in handling radioisotopes. Biological applications of radioisotopes.

**Spectroscopic Techniques:** Beer-Lambert law, light absorption and its transmittance, extinction coefficient, a brief account of instrumentation and applications of visible and UV spectroscopic techniques (structure elucidation excluded).

**Suggested reading:**

1. Principles & Techniques of Biochemistry & Molecular Biology, 7th edition, by Keith Wilson and John Walker (2018).
2. Biophysical Chemistry: Principles and Techniques, by A. Upadhyay, K. Upadhyay and N.Nath. (2016). Himalaya Publishing House, Delhi.
3. Physical Biochemistry, 2nd edition, by D Friefelder (1983). W.H. Freeman & Co., U.S.A.
4. Introductory Practical Biochemistry by S.K. Sawhney and Randhir Singh (2000). Narosa Publishing House, New Delhi.

**Semester-V**

**DSE–BIOCHEMISTRY-1**

**Paper B-BCH-501**

**Immunology-1**

**Credits: 2**

**Total Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Examination Time: 3 h**

**Learning outcomes:**

After successful completion of course, students will be able to

* 1. Exhibit the knowledge of basic components, organs, cells of immune system, components of immunity and will understand the coordination between humoral, cell-mediated and innate immune responses in combating pathogens
	2. Illustrate the attributes of antigens, immunogens, factors affecting immunogenicity; the structure and functions of different types of immunoglobulins

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**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each section. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each section. All questions carry equal marks.

**SECTION –A**

**Introduction to immune system**: Historical Perspective, Cells and organs of the immune system; primary and secondary lymphoid organs; bone marrow, thymus, spleen, lymphnodes and tissues (MALT)

 **Components of immunity:** Innate immunity- Anatomic, physiological, phagocytic and inflammatory barriers; Adaptive immunity- A brief account of the functions of Humoral and cell-mediated immune responses. Primary and secondary immune responses, connection between innate and adaptive immunity, cell adhesion molecules, chemokines, leukocyte extravasation, localized and systemic response

**Antigens:** Antigens and haptenes**,** Immunogenicity versus antigenicity, factors influencing immunogenicity; Adjuvants; Epitopes (properties of B-Cell and T-cell epitopes)

**SECTION –B**

**Immunoglobulins**: Structure, distribution of classes and subclasses of immunoglobulins, physicochemical properties of different classes of immunoglobulins, antigenic determinants on immunoglobulins and Ig superfamily

**Monoclonal Antibodies**: Introduction, formation and selection of hybrid cells, their production and applications.

**Biology of B lymphocytes**: Antigen independent phase of B cell maturation and selection, humoral response- Thymus dependent and Thymus independent response, anatomical distribution of B-cell population

**Suggested Readings:**

1. Kuby “Immunology” 8th edn. (2018), WH Freeman Publishers
2. Immunology” 8th edn. David Male Jonathan Brostoff David Roth Ivan Roitt, 2012.
3. Janeway’s Immunobiology 2012 8th ed., Murphy, K., Mowat, A., and Weaver, C.T., Garland Science (London & New York), ISBN:978-0-8153-4243-4

**Semester-V**

**DSE–BIOCHEMISTRY-1**

**Paper B-BCH-502**

**Immunology-II**

**Credits: 2**

**Total Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Examination Time: 3 h**

**Learning outcomes:** After successful completion of course, students will be able to

502.1 Understand the basis and applications of antigen antibody interactions disease diagnosis and exhibit the knowledge of different modes of complement activation, types of MHCs and their role in antigen presentation and processing

* 1. Illustrate structures and functions of various components of cell mediated immune response; the principles of tolerance, autoimmunity anddifferent types of hypersensitivity

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each section. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each section. All questions carry equal marks.

**SECTION-A**

**Antigen–antibody interactions**: Antibody affinity, antibody avidity, Agglutination & Precipitation reactions; Immunodiffusion; Radio immunoassay & ELISA.

**Complement system:** Components if complement system,Complement activation by classical, alternate and MB lactin pathways**,** Biological consequences of complement activation and regulation.

**Major Histocompatibility Complex (MHC**): General organization and inheritance of MHC, Structure, distribution and role of class I & II MHC molecules;.

**Antigen Processing & Presentation**: A brief account of antigen processing and presentation pathways.

**SECTION-B**

**Biology of the T lymphocyte:** Structure and role of T cell receptor, and co-receptor, T cell development, generation of receptor diversity, selection and differentiation.

**Cell mediated cytotoxic responses**: General properties of effector T cells, cytotoxic T cells (Tc), natural killer cells; NKT cells and antibody dependent cellular cytotoxicity (ADCC).

**Tolerance, autoimmunity and hypersensitivity**: Central tolerance, pherpheral tolerance, autoimmunity, autoimmune diseases, possible mechanisms of induction of autoimmunity, Hypersensitivity reactions: Gell and Coombs classification, IgE mediated (Type I) hypersensitivity, antibody mediated cytotoxic (Type II) hypersensitivity, immune complex mediated (type III) hypersensitivity and delayed type (Type IV) hypersensitivity.

**Transplantation immunology and vaccines**: Immunological basis of graft rejection, clinical manifestations, Vaccines - active and passive immunization

**Suggested Reading:**

1. A Short Course in Immunology by Benjamini
2. Kuby “Immunology” 8th edn. (2018), WH Freeman Publishers
3. Immunology” 8th edn. David Male Jonathan Brostoff David Roth Ivan Roitt, 2012.
4. Janeway’s Immunobiology 2012 8th ed., Murphy, K., Mowat, A., and Weaver, C.T., Garland Science (London & New York), ISBN:978-0-8153-4243-4

**Semester-V**

**DSE–BIOCHEMISTRY-1**

**Paper B-BCH-503**

**Immunology-Practical’s**

**Credits: 2**

**Total Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Examination Time: 3 h**

**Learning outcomes:** After successful completion of course, students will be able to

503.1 Exhibit skills to isolate lymphocytes from blood/spleen and to perform various immunoassays such as Ouchterlony double immunodiffusion (DID), Western Blotting, ELISA for diagnosis of various diseases.

503.2 perform techniques to purify immunoglobulins and the blood typing.

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Isolation of lymphocytes from blood / spleen.

2. Ouchterlony double immunodiffusion (DID)

3. Purification of immunoglobulins

4. Demonstration of Western Blotting

5. Assays based on agglutination reactions - Blood typing

6. Enzyme linked immunosorbent assay (ELISA)

Suggested Readings:

1. Immunology – Janis Kuby – W. H. Freeman and Co. 7th edition (2019)
2. Janeway’s Immunobiology 2012 8th ed., Murphy, K., Mowat, A., and Weaver, C.T., Garland Science (London & New York), ISBN:978-0-8153-4243-4
3. I.M. Riott, J. Brostoff, D. Male “Immunology” 3rd edn. W.H. Freeman and Pub. Company, USA.
4. Kuby “Immunology” 3rd edn., Mosby Year Book Co., England  Introduction to Immunology – NandiniShetty (2003)

**Semester – V**

**DSE-BIOCHEMISTRY-1**

**Paper: B-BCH-504**

**Plant Biochemistry-I**

 **Credits: 2**

**Total Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Examination Time: 3 h**

**Learning Outcomes:** Students who successfully complete this course will be able to

504.1 Exhibit the knowledge of structure and energy generation by the photosynthetic apparatus; CO2 assimilation by different pathways and photorespiration

* 1. Elaborate structural organization and functioning of ETC in chloroplast and mitochondria; sulfur metabolism and role of hormones in plant growth.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each section. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each section. All questions carry equal marks.

**SECTION-A**

**Photosynthesis** – Photosynthetic apparatus, pigments of photosynthesis, role of carotenoids, photosystems I and II, their location; Hill reaction, photosynthetic electron transport and generation of NADPH & ATP, cyclic and non-cyclic photophosphorylations, complexes associated with thylakoid membranes; light harvesting complexes,

**Photosynthetic CO2 Assimilation**: path of carbon in photosynthesis – C3 and C4 pathway of carbon reduction and its regulation, CAM pathway

**Photorespiration**; organelles involved in photorespiration, C2 cycle, correlation of photosynthesis and photorespiration, importance of photorespiration for plants

**SECTION –B**

**Electron transport system in plants**: oxidative phosphorylation, mitochondrial respiratory complexes, order and organization of electron carriers, electrochemical gradient, chemiosmotic theory, ATP synthase and mechanism of ATP synthesis, difference in chloroplast and mitochondrial electron transport chain, difference in animal and plant electron transport chain

##### **Sulphate assimilation**: Sulphate uptake; reduction of sulfate (free and intermediate bound ), sulfite reductase, structure and energy required by sulfate reductase and sulfite reductase, assimilation of sulphate into cysteine and methionine

**Plant Hormones**: Structures, translocation and physiological functions of Auxins, Gibberllins, cytokinins, Ethylene, Abscisic acid

**Suggested Reading:**

1. Biochemistry and Molecular Biology of Plants, 2nd Edi by Bob, B. Buchanan (2015)
2. Plant Biochemistry & Molecular Biology, 3rd ed., by Hans –Walter Heldt (2005), Academic Press.
3. Plant Biochemistry and Molecular Biology, 2nd edition, by Peter J. Lea and Richard C. Leegood (1999). John Wiley and Sons.
4. Plant physiology, 3rd edition, by L. Taiz and E-Zeigler (2003)

**Semester – V**

**DSE-BIOCHEMISTRY-1**

**Paper: B-BCH-505**

**Plant Biochemistry-II**

 **Credits: 2**

**Total Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Examination Time: 3 h**

**Learning Outcomes:** Students who successfully complete this course will be able to

* 1. Exhibit the knowledge of nitrogen fixation and assimilation process in plants with structure and regulation of enzymes: nitrogenogenase, nitrate reductase and nitrite reductase
	2. Illustrate secondary metabolic pathways and their importance; various stressful conditions of the environment that affect growth and defense mechanisms in plants.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each section. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each section. All questions carry equal marks.

 **SECTION-A**

**Nitrogen metabolism**: Nitrate uptake, structural features of nitrate reductase and nitrite reductase, incorporation of ammonia into organic compounds, regulation of nitrate assimilation.

**Biological N2-fixation**: Biological nitrogen fixation by free living and in symbiotic association; structure, functionand mechanism of action of the enzyme nitrogenase, strategies for protection of nitrogenase from inhibition by oxygen; structure of nodule, role of leghaemoglobin;

**Ammonia assimilation:** Synthesis of amides and ureides**,** transport of assimilated nitrogen to aerial parts.

##### **SECTION-B**

**Secondary metabolites**: Special features of secondary plant metabolism, terpenes, lignin, tannins, pigments, phytochrome, waxes, alkaloids, nicotine, functions of alkaloids, cell wall components.

**Toxins of plant origin** – mycotoxins, phytohemagglutinins, lathyrogens, nitriles, protease inhibitors, protein toxins.

**Stress metabolism in plants** – Environmental stresses, salinity, water stress, heat, chilling, anaerobiosis, pathogenesis, heavy metals, radiations and their impact on plant growth and metabolism, criteria of stress tolerance.

##### **Antioxidative defense system in plants** – reactive oxygen species and their generation, enzymic and non-enzymic components of antioxidative defense mechanism.

**Suggested Reading:**

1. Biochemistry and Molecular Biology of Plants, 2nd Edi by Bob, B. Buchanan (2015)
2. Plant Biochemistry & Molecular Biology, 3rd ed., by Hans –Walter Heldt (2005), Academic Press.
3. Plant Biochemistry and Molecular Biology, 2nd edition, by Peter J. Lea and Richard C. Leegood (1999). John Wiley and Sons.
4. Plant physiology, 3rd edition, by L. Taiz and E-Zeigler (2003)

**Semester – V**

**DSE-BIOCHEMISTRY-1**

**Paper: B-BCH-506**

**Plant Biochemistry-Practicals**

**Credits: 2**

**Total Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Examination Time: 3 h (one session)**

**Learning Outcomes:** After successful completion students will be able to

* 1. Extract and determine quantitatively the contents and the spectral patterns of photosynthetic pigments
	2. Extract and determine content of phenols and tannins in plant samples and explore antioxidant property of plant extracts

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**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Extraction and estimation of chlorophylls from grass/spinach leaves
2. Extraction and estimation of carotenoids from grass/spinach leaves
3. Separation of photosynthetic pigments by chromatography and determination of absorption
4. Extraction and estimation of total phenols in plant samples
5. Estimation of tannins in fruits and vegetables
6. Determination of radical scavenging activity of plant extracts

### Suggested Reading:

1. An introduction to Practical Biochemistry, 3rd Edition, by David Plummer (2017). Tata Mc-Graw Hill
2. Introductory Practical Biochemistry by S.K.Sawhney & R. Singh (2014). Narosa Publishers
3. Modern Experimental Biochemistry, 3rd edition, by R. Boyer (2002) Addison-Wesley Longman.
4. Biochemical Methods by Sadasivam & Manickam (1996) New Age International (P) Ltd.
5. A Lab. Manual in Biochemistry by J. Jayaraman (1996) New Age International (P) Ltd.

**Semester – VI**

**DSE-BIOCHEMISTRY-2**

**Paper: B-BCH-601**

**Clinical Biochemistry-I**

 **Credits: 2**

**Total Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Examination Time: 3 h**

**Learning outcomes:**

After successful completion of course, students will be able to

* 1. Demonstrate the knowledge of various types of hormones, acid base balance, the normal and abnormal constituents of urine, blood, detoxification reactions and their significance in maintaining good health.
	2. Give an insight (enzyme responsible, biochemical impact and clinical symptoms) of metabolic disorders of carbohydrates, lipids, proteins, nucleic acids and the role of isoenzyme pattern in health and disease

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

 Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each section. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each section. All questions carry equal marks.

**SECTION – A**

Hormones: General characteristics, classes with examples, major endocrine systems and their target tissues, physiological roles of hormones, Role of cyclic nucleotides and calcium in hormones action; Mechanism of action of epinephrine and steroid hormones.

Minerals: Functions of various major and trace minerals.

Acid- Base balance, Electrolyte Balance

Collection and preservation of biological fluids (blood, serum, plasma, urine and CSF). Normal and abnormal constituents of blood and urine. Plasma proteins. Mechanism of blood coagulation.

Detoxification mechanism of the body: Phase I and phase II pathways.

**SECTION-B**

Metabolic Disorders: Biochemical aspects of diabetes mellitus, Metabolic disorders of carbohydrate (Hypo- and hyper-glycemia, galactosemia, lactose intolerance, glycogen storage diseases), lipid (Sphingolipidosis, atherosclerosis, lipoproteinemia), protein (Phenylketonuria, alkaptonuria, tyrosenimea, maple syrup urine disease, Hartnup’s disease, homocysteinuria etc.) and nucleic acids (Gout, Lesch-Nyhan syndrome).

Clinical enzymology: Definition of functional and non-functional plasma enzymes. Enzyme and isoenzyme pattern in health and disease with special mention of plasma lipase, amylase, SGOT, SGPT, LDH, CPK, alkaline phosphatase and acid phosphatase.

**Suggested readings:**

1. Teitz text book of clinical chemistry (1999), 3rd edition, Carl A. Burtis and Edward R. Ashwood, W. B. Saunders Company.
2. Harper’s Biochemistry, 26th edition, by R.K.Murray, P.A.Hayes, D.K.Granner, P.A. Mayes and V.W.Rodwell (2003) Prentice Hall International.
3. Textbook of Biochemistry with Clinical Correlations, 5thed. by T.M. Devlin (2002).Wiley-liss.
4. Biochemistry by U. Satyanarayana (2002). Books and allied (P) Ltd.
5. Text Book of Biochemistry & Human Biology by G.P. Talwar (1989) Prentice Hall, New Delhi

 **Semester – VI**

**DSE-BIOCHEMISTRY-2**

**Paper: B-BCH-602**

**Clinical Biochemistry-II**

**Credits: 2**

**Total Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Examination Time: 3 h**

**Learning outcomes:**

After successful completion of course, students will be able to

602.1 Demonstrate the knowledge of various clinical conditions related to nutritional deficiencies and faulty life style

602.2 Understand and analyse the relationship of environmental factors and genetic makeup in the onset of multifactorial diseases: protein misfold diseases and epidemic diseases.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each section. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each section. All questions carry equal marks.

**SECTION – A**

**Nutritional disorders**

Overview of major and minor nutrient components in the diet. Balanced diet and the concept of RDA. Nutrient deficiencies; Kwashiorkor and Marasmus, Scurvy, beri beri, pellagra and B12 deficiency, Xerophthalmia and Night blindness, Vitamin D deficiency, Vitamin K deficiency.

**Lifestyle disorders**

Obesity, Type-2-Diabetes mellitus, Cardio vascular disorders and Thyroidism. Irritable bowel syndrome- biochemistry behind the disorder and the influence of diet, stress and environment on the condition

**SECTION – B**

**Multifactorial complex disorders and Cancer**

Understanding the definition of multifactorial diseases. Polygenic diseases and the relationship of environmental factors and genetic makeup in the onset of diseases; Cancer, Parkinson’s disease, ALS, Skeletal muscle atrophy

**Diseases due to misfolded proteins**

Introduction to protein folding and proteosome removal of misfolded proteins; etiology and molecular basis for Alzheimer's, sickle cell anemia, Thalassemia.

**Pandemic and epidemic diseases:**

Pandemic versus epidemic diseases; history, causative agents and pathogenesis of Chikungunya, Cholera, Ebola virus disease, Novel coronavirus (2019-nCoV), Smallpox, Yellow fever, Zika virus disease, Polio

**Suggested readings:**

1. Teitz text book of clinical chemistry (1999), 3rd edition, Carl A. Burtis and Edward R. Ashwood, W. B. Saunders Company.
2. Harper’s Biochemistry, 26th edition, by R.K.Murray, P.A.Hayes, D.K.Granner, P.A. Mayes and V.W.Rodwell (2003) Prentice Hall International.
3. Textbook of Biochemistry with Clinical Correlations, 5thed. by T.M. Devlin (2002).Wiley-liss.
4. Biochemistry by U. Satyanarayana (2002). Books and allied (P) Ltd.
5. Text Book of Biochemistry & Human Biology by G.P. Talwar (1989) Prentice Hall, New Delhi

**Semester – VI**

**DSE-BIOCHEMISTRY-2**

**Paper: B-BCH-603**

**Clinical Biochemistry-Practicals**

 **Credits: 2**

**Total Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Examination Time: 3 h (one session)**

**Learning outcomes:**

After successful completion of course, students will be able to

* 1. Qualitative analysis of normal and abnormal constituents of urine
	2. Quantitative analysis of constituents of blood and their estimation using standard methods

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Qualitative analysis of abnormal constituents in urine – proteins, Bence-Jones proteins glucose, bile pigments, bile salts and ketone bodies, Cl- and Ca+2
2. Separation of serum and plasma from blood sample
3. Estimation of serum cholesterol
4. Estimation of haemoglobin by cyanmethemoglobin method
5. Determination of A/G ratio in serum
6. Serum enzyme assays: alkaline phosphatase/SGOT/SGPT

### Suggested readings:

1. Introductory Practical Biochemistry by S.K.Sawhney & R. Singh (2000). Narosa Publishers
2. Practical Biochemistry by David Plummer (1990). Tata Mc-Graw Hill
3. Biochemical Methods by Sadasivam & Manickam (1996) New Age International (P) Ltd.
4. Modern Experimental Biochemistry, 3rd edition, by R. Boyer (2002) Addison-Wesley Longman.

**Semester – VI**

**DSE-BIOCHEMISTRY-2**

**Paper: B-BCH-604**

**Nutritional Biochemistry-1**

**Credits: 2**

**Total Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Examination Time: 3 h**

**Learning Outcomes:** After successful completion students will be able to

604.1 Exhibit the knowledge of the importance of nutrition with reference to energy metabolism, glycemic index, carbohydrate digestion, absorption and factors influencing availability of different types

604.2 Describe the factors affecting availability, process of digestion and absorption of different types of lipids, amino acids and proteins; Deficiency diseases of lipids and proteins

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each section. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each section. All questions carry equal marks.

**SECTION-A**

**Introduction to Nutrition and Energy Metabolism:** Defining Nutrition, role of nutrients, Units of energy, Biological oxidation of food stuff, measurement of energy content of food, Physiological energy value of foods, SDA, Factors affecting energy input - hunger, appetite, Energy balance, Energy expenditure, Estimating energy requirements- Direct and Indirect Calorimetry, Factors affecting thermogenesis, Energy utilization by cells, energy output – Basal and Resting metabolism, physical activity, Factors affecting BMR, Recommended Nutrient Intakes (RNI) and Recommended Dietary Allowances for different age groups.

**Dietary Carbohydrates and health:**  Review functions of carbohydrates. Digestion, absorption, utilization and storage, hormonal regulation of blood glucose. Dietary requirements and source of carbohydrates, Dietary fibre

**SECTION-B**

**Dietary lipid and health:**  Review of classification, sources, functions, digestion, absorption, utilization and storage. Essential Fatty Acids; Functions of EFA, RDA, – excess and deficiency of EFA. Lipotropic factors, role of saturated fat, cholesterol, lipoprotein and triglycerides. Importance of the following: unsaturated and Saturated Fatty Acids

**Dietary Proteins and health:** Review of functions of proteins in the body, Digestion and absorption of dietary proteins, Essential and Non- essential amino acids, Amino Acid availability, Antagonism, Toxicity and Imbalance, Amino acid pool, NPU, Biological Value; Protein calorie malnutrition - Kwashiorkar and Marasmus.

**Suggested readings:**

1. Textbook of Biochemistry with Clinical Correlations (2011) Devlin, T.M. John Wiley & Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.
2. Nutrition for health, fitness and sport (2013); Williams.M.H, Anderson, D.E, Rawson, E.S. McGraw Hill international edition. ISBN-978-0-07-131816-7.
3. Krause’s Food and Nutrition Care process. (2012); Mahan, L.K Strings, S.E, Raymond, J. Elsevier’s Publications. ISBN- 978-1-4377-2233-8.
4. The vitamins, Fundamental aspects in Nutrition and Health (2008); G.F. Coombs Jr. Elsevier’s Publications. ISBN-13- 978-0-12- 183493-7.
5. Principles of Nutritional Assessment (2005) Rosalind Gibson. Oxford University Press.
6. Debojyoti Das’s Biochemistry Book

 **Semester – VI**

**DSE-BIOCHEMISTRY-2**

**Paper: B-BCH-605**

**Nutritional Biochemistry- II**

 **Credits: 2**

**Total Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Examination Time: 3 h**

**Learning Outcomes:** After successful completion students will be able to

* 1. Illustrate the relationship between vitamins, metabolism and health: antinutritional factors and their impact on health
	2. Elaborate the biochemical functions of major and minor minerals and discuss the interaction between drugs and nutrients; nutraceuticals

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each section. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each section. All questions carry equal marks.

**SECTION-A**

**Fat and water soluble Vitamins**: Vitamin A, C, E, K and D dietary sources, RDA, adsorption, distribution,Hypervitaminosis, Deficiency; Role of Vitamin A as an antioxidant, in Visual cycle, dermatology and immunity; Role of Vitamin K in Gamma carboxylation; Role of Vitamin E as an antioxidant; Extra-skeletal role of Vitamin D and its effect on bone physiology; Hypervitaminosis; role of Vitamin C as cofactor in amino acid modifications. Niacin- Metabolic interrelation between tryptophan, Niacin and NAD/ NADP; Vitamin B6-Dietary source, RDA, conversion to Pyridoxal Phosphate, role in metabolism, biochemical basis for deficiency symptoms; Vitamin B12 and folate- Dietary source, RDA, absorption, metabolic role biochemical basis for deficiency symptoms.

**Antinutritional factors**: Sources and harmful effects of antivitamins (egavidin, dicoumarol), natural toxicants (eg. Lathyrussativa) and adulterants (eg. butter yellow, lead chromate, malachite green).

**SECTION-B**

**Minerals:** Calcium, Phosphorus and Iron - Distribution in the body digestion, Absorption, Utilization, Transport, Excretion, Balance, Deficiency, Toxicity, Sources, RDA. Calcium: Phosphorus ratio, Role of iron in prevention of anemia. Iodine and iodine cycle. Iodine, Fluoride, Mg, Cu, Zn, Se, Manganese, Chromium, Molybdenum Distribution in the human body, Physiology, Function, deficiency, Toxicity and sources with special reference to Arsenic

**Water metabolism:** Distribution of water in body fluids, Regulation of water metabolism.

**Food and drug interactions and Nutraceuticals**: Alcohol, chewing tobacco and nutrient deficiency, Anti- depressants, psychoactive drugs and nutrient interactions, Appetite changes with drug intakes and malnutrition. Food as medicine.

**Suggested Readings**

1. Textbook of Biochemistry with Clinical Correlations (2011) Devlin, T.M. John Wiley & Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.
2. Nutrition for health, fitness and sport (2013); Williams.M.H, Anderson, D.E, Rawson, E.S. McGraw Hill international edition. ISBN-978-0-07-131816-7.
3. Krause’s Food and Nutrition Care process. (2012); Mahan, L.K Strings, S.E, Raymond, J. Elsevier’s Publications. ISBN- 978-1-4377-2233-8.
4. The vitamins, Fundamental aspects in Nutrition and Health (2008); G.F. Coombs Jr. Elsevier’s Publications. ISBN-13- 978-0-12- 183493-7.
5. Principles of Nutritional Assessment (2005) Rosalind Gibson. Oxford University Press.
6. Debojyoti Das’s Biochemistry Book

**Semester – VI**

**DSE-BIOCHEMISTRY-2**

**Paper: B-BCH-606**

**Nutritional Biochemistry- Practicals**

**Credits: 2**

**Total Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Examination Time: 3 h (one session)**

**Learning Outcomes:** After successful completion students will be able to

* 1. Quantitatively analyse the sample for sugar, vitamin and phenol content
	2. Quantitatively analyse the sample for minerals

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Extraction and estimation of total phenolic content from black-Tea.
2. Extraction and estimation of flavonoid content from spices.
3. Determination of iodine number from vegetable oil.
4. Estimation of calcium from milk.
5. Estimation of phosphorous from milk.
6. Estimation of lactose in milk

### Suggested reading:

1. Introductory Practical Biochemistry by S.K.Sawhney & R. Singh (2000). Narosa Publishers
2. Practical Biochemistry by David Plummer (1990). Tata Mc-Graw Hill
3. Biochemical Methods by Sadasivam & Manickam (1996) New Age International (P) Ltd.
4. Modern Experimental Biochemistry, 3rd edition, by R. Boyer (2002) Addison-Wesley Longman.

**Programme Outcomes (POs) for UG courses of Faculty of Life Sciences**

1. To develop skills in graduate students to be able to acquire theoretical and practical knowledge in fundamentals of biology in respective disciplines of plants, animals, microbes and environment.
2. To inculcate ability to critically evaluate problems and apply lateral thinking and analytical skills for professional development.
3. To create awareness on ethical issues, good laboratory practices and biosafety.
4. To develop ability in youth for understanding basic scientific learning and effective communication skills.
5. To prepare youth for career in teaching, industry, government organizations and self reliant entrepreneurship.
6. To make students aware of natural resources and environment and its sustainable utilization.
7. To provide learning experience in students that instills deep interest in biological science for the benefit of society.

**Programme Specific Outcomes (PSOs) for UG courses in Biochemistry**

After the successful completion of the course the student will be able to

1. **PSO1-** To demonstrate the knowledge and understanding of biochemistry, structure and function of biological molecules, biological mechanisms, such as the processes and control of bioenergetics and metabolism, as chemical reactions
2. **PSO2-** critically think and correlate the biochemical knowledge day to day routine to improve quality of life in person & community in general
3. **PSO3-** Demonstrate and understanding of the principles of biochemical techniques and exhibit basic professional skills pertaining to biochemical analysis carry out laboratory-orientated numerical calculations and analyze biochemical data (e.g. in enzyme kinetics, molecular structure analysis, clinical analysis, immunological inferences)
4. **PSO4-** demonstrate the scientific writing and authentic reporting, effective presentation skills and ability to work in a group in collaboration and with cooperation

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| **CORE COURSE - BIOCHEMISTRY-1****Molecules of Life** |
| **CO#** | After the successful completion of the course the student will be able to |
| **101.1** | Describe the basic chemistry and properties of water; physiological buffers; Classify, define and explain various properties of carbohydrates and correlate them to their functions |
| **101.2** | Classify, define, draw structures and explain functions of various types of lipids: Illustrate various parameters of characterization of lipids. |
| **102.1** | Classify, draw structures of standard amino acids, explain chemical and physical properties of amino acids; Describe different classes of proteins and explain different levels of structural organization in protein architecture. |
| **102.2** | Explain the characteristics and draw structures of various types of nucleic acids;Illustrate chemical and physical properties, structures and biological functions of porphyrins |
| **103.1** | Prepare various types of solutions used in qualitative and quantitative biochemical estimations; verify and apply the basic principles of spectroscopy |
| **103.2** | Analyse the unknown samples qualitatively for the presence of various biomolecules |

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| **CORE COURSE-BIOCHEMISTRY-1****Molecules of Life** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **101.1** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **101.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **102.1** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **102.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **103.1** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | - | 3 | 3 | 3 |
| **103.2** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 |
| **Average** | 3 | 3 | 2 | 3 | 3 | 2.83 | 2.66 | 2.5 | 3 | 2.33 | 3 |

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| **CORE COURSE - BIOCHEMISTRY-2****ENZYMES** |
| CO# | After the successful completion of the course the student will be able to |
| **201.1** | Define various characteristics of enzymes, classify them and elaborate the role of cofactors in enzyme catalysis |
| **201.2** | Correlate the structure of enzymes to their functions, mechanism of enzyme catalysis and describe various approaches for purification of enzymes  |
| **202.1** | Exhibit the knowledge of enzyme kinetics of unisubstrate reactions, various kinetics parameters (Km, Vmax etc.) and describe different types of enzyme inhibitions.  |
| **202.2** | Correlate different ways of enzyme regulation to cellular metabolism: discuss and analyse the industrial importance of enzymes and the techniques to use them |
| **203.1** | Extract and quantitatively estimate the enzyme activity and protein content of the samples |
| **203.2** | Exhibit skills in studying various characteristics of enzymes like pH optima, temperature optima, Km, Vmax |

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| **CORE COURSE-BIOCHEMISTRY-2****ENZYMES** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **201.1** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 |
| **201.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **202.1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **202.2** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **203.1** | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 2 | 3 | 3 | 3 |
| **203.2** | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 3 | 3 | 3 |
| **Average** | 3 | 3 | 2 | 3 | 3 | 2.33 | 2.66 | 2.83 | 2.83 | 2.5 | 3 |

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|  **CORE COURSE - BIOCHEMISTRY-3****Metabolism** |
| CO# | After the successful completion of the course the student will be able to |
| **301.1** | Apply the knowledge of biological redox reactions, coupled reactions, energy rich compounds and the energy transactions in studying metabolism; describe the metabolic pathways i.e. glycolysis (catabolism), gluconeogensis (anabolism), and TCA cycle and their regulations  |
| **301.2** | Discuss the reactions, regulation and importance of pentose phosphate pathway, glycogen metabolism, glyoxylate, ETC and apply the concept of oxidative phosphorylation to calculate energy production by oxidation of carbohydrates |
| **302.1** | Describe the reactions and regulation of lipid biosynthesis and catabolism by beta, alpha and omega oxidative pathways: ketone bodies metabolism and integration to the metabolism of other biomolecules  |
| **302.2** | Analyse how amino acid catabolism leads to formation of diverse type molecules including ketone bodies, glucose, urea: discuss the catabolism and anabolismof nucleic acids and porphyrins |
| **303.1** | Determine biomolecules in the samples quantitatively. |
| **303.2** | Isolate and characterize carbohydrates, lipids and proteins from the natural sources |

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| **CORE COURSE-BIOCHEMISTRY-3****Metabolism** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **301.1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **301.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **302.1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **302.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **303.1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **303.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **Average** | 3 | 3 | 2.66 | 3 | 3 | 3 | 3 | 2.66 | 2.83 | 2.83 | 3 |

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| **CORE COURSE - BIOCHEMISTRY-4****Molecular Biology** |
| CO# | After the successful completion of the course the student will be able to |
| **401.1** | Elaborate the central dogma of life at molecular level and the general principles of gene organization, DNA supercoiling; nucleases and various approaches of sequencing of DNA |
| **401.2** | Describe the structure and functions of proteins involved in replication and mechanism of DNA replication and correlate molecular basis of different types of DNA mutations with the repair systems of the mutations  |
| **402.1** | Give an insight of the process of gene expression, mechanism of transcription, post-transcriptional processing of RNA in prokaryotes; Describe and correlate the concept of genetic code and mechanism of translation in prokaryotes  |
| **402.2** | Describe the process of regulation of gene expression in prokaryotes and exhibit the knowledge of basics of recombinant technology for the manipulation of genetic information stored in the cells with the help of diverse cloning vectors |
| **403.1** | Isolate and quantify genetic material from plant/animal sources by colorimetric methods |
| **403.2** | Exhibit the skill in separating the fragments of DNA by electrophoresis and characterizing by absorption spectrum.  |

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| **CORE COURSE-BIOCHEMISTRY-4****Molecular Biology** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **401.1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **401.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **402.1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **402.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **403.1** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 |
| **403.2** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 |
| **Average** | 3 | 3 | 2 | 3 | 3 | 3 | 2.66 | 2.66 | 3 | 2.83 | 3 |

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| **DISCIPLINE SPECIFIC COURSE – BIOCHEMISTRY****Immunology** |
| CO# | After the successful completion of the course the student will be able to |
| **501.1** | Exhibit the knowledge of basic components, organs, cells of immune system, components of immunity and will understand the coordination between humoral, cell-mediated and innate immune responses in combating pathogens |
| **501.2** | Illustrate the attributes of antigens, immunogens, factors affecting immunogenicity; the structure and functions of different types of immunoglobulins |
| **502.1** | Understand the basis and applications of antigen antibody interactions disease diagnosis and exhibit the knowledge of different modes of complement activation, types of MHCs and their role in antigen presentation and processing**.** |
| **502.2** | Illustrate structures and functions of various components of cell mediated immune response; the principles of tolerance, autoimmunity and different types of hypersensitivity |
| **503.1** |  Exhibit skills to isolate lymphocytes from blood/spleen and to perform various immunoassays such as Ouchterlony double immunodiffusion (DID), Western Blotting, ELISA for diagnosis of various diseases.  |
| **503.2** | Perform techniques to purify immunoglobulins and the blood typing.  |

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| **DISCIPLINE SPECIFIC COURSE - Immunology** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **501.1** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 |
| **501.2** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 |
| **502.1** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 |
| **502.2** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 2 | 3 |
| **503.1** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 |
| **503.2** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 |
| **Average** | 3 | 3 | 2.33 | 3 | 3 | 2 | 2.66 | 2.66 | 2.33 | 2.83 | 3 |

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| **DISCIPLINE SPECIFIC COURSE – BIOCHEMISTRY****Plant Biochemistry** |
| **CO#** | After the successful completion of the course the student will be able to |
| **504.1** | Exhibit the knowledge of structure and energy generation by the photosynthetic apparatus; CO2 assimilation by different pathways and photorespiration  |
| **504.2** | Elaborate structural organization and functioning of ETC in chloroplast and mitochondria; sulfur metabolism and role of hormones in plant growth |
| **505.1** | Exhibit the knowledge of nitrogen fixation and assimilation process in plants with structure and regulation of enzymes: nitrogenogenase, nitrate reductase and nitrite reductase |
| **505.2** | Illustrate secondary metabolic pathways and their importance; various stressful conditions of the environment that affect growth and defense mechanisms in plants |
| **506.1** | Extract and determine quantitatively the contents and the spectral patterns of photosynthetic pigments  |
| **506.2** | Extract and determine content of phenols and tannins in plant samples and explore antioxidant property of plant extracts  |

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| **DISCIPLINE SPECIFIC COURSE- Plant Biochemistry** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **504.1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **504.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **505.1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **505.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **506.1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **506.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **Average** | 3 | 3 | 2.33 | 3 | 3 | 3 | 3 | 2.5 | 3 | 2.83 | 3 |

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| **DISCIPLINE SPECIFIC COURSE – BIOCHEMISTRY****Clinical Biochemistry** |
| CO# | After the successful completion of the course the student will be able to |
| **601.1** | Demonstrate the knowledge of various types of hormones, acid base balance, the normal and abnormal constituents of urine, blood, detoxification reactions and their significance in maintaining good health. |
| **601.2** | Give an insight (enzyme responsible, biochemical impact and clinical symptoms) of metabolic disorders of carbohydrates, lipids, proteins, nucleic acids and the role of isoenzyme pattern in health and disease |
| **602.1** | Demonstrate the knowledge of various clinical conditions related to nutritional deficiencies and faulty life style  |
| **602.2** | Understand and analyse the relationship of environmental factors and genetic makeup in the onset of multifactorial diseases: protein misfold diseases and epidemic diseases.  |
| **603.1** | Qualitative analysis of normal and abnormal constituents of urine |
| **603.2** | Quantitative analysis of constituents of blood and their estimation using standard methods |

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| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **601.1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **601.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **602.1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **602.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **603.1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **603.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **Average** | 3 | 3 | 2.33 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

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| **DISCIPLINE SPECIFIC COURSE – BIOCHEMISTRY****Nutritional Biochemistry** |
| CO# | After the successful completion of the course the student will be able to |
| **604.1** | Exhibit the knowledge of the importance of nutrition with reference to energy metabolism, glycemic index, carbohydrate digestion, absorption and factors influencing availability of different types  |
| **604.2** | Describe the factors affecting availability, process of digestion and absorption of different types of lipids, amino acids and proteins; Deficiency diseases of lipids and proteins |
| **605.1** | Illustrate the relationship between vitamins, metabolism and health: anti-nutritional factors and their impact on health |
| **605.2** | Elaborate the biochemical functions of major and minor minerals and discuss the interaction between drugs and nutrients; nutraceuticals |
| **606.1** | Quantitatively analyse the sample for sugar, vitamin and phenol content |
| **606.2** | Quantitatively analyse the sample for minerals |

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| **DISCIPLINE SPECIFIC COURSE- Nutritional Biochemistry** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **601.1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **601.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **602.1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **602.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **603.1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **603.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **Average** | 3 | 3 | 2.33 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |