

**DEPARTMENT OF BIOCHEMISTRY**  
**BSc (H) Biochemistry**  
*Category-I*

**DISCIPLINE SPECIFIC CORE COURSE -1 (DSC-1) – : Biomolecules**

**Credit distribution, Eligibility and Prerequisites of the Course**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre- requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Biomolecules  DSC_1	4	2	0	2	Class XII Science Combination I: Chemistry + Biology/ Biological Studies/ Biotechnology/ Biochemistry +	NIL

					Physics OR Combination II: Chemistry + Biology/ Biological Studies/ Biotechnology/ Biochemistry + Mathematics	
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### Learning Objectives

This paper will provide an understanding of biomolecules, the basic building blocks of living organisms, focusing on their structural underpinnings, unique properties of molecules, biological roles and functions for students. Emphasis will be on the association between structure and function of various biomolecules at a chemical level with a biological perspective and hands-on approach and laboratory techniques.

### Learning outcomes

On successful completion of the course students will be:

- Able to comprehend the structure, function and acid-base properties of amino acids.
- Introduced to the structure, properties and roles of carbohydrates, lipids and nucleic acids.
- Aware of the importance of vitamins in biological systems.
- Able to independently identify various biomolecules in the laboratory by qualitative test methods.
- Acquainted with chemical and molecular foundations of life and appreciate the role of buffer in biological systems.

## SYLLABUS OF DSC - 1

### THEORY

#### Unit – 1

(07 Hours)

**Amino acids:** Amino acids as bifunctional molecules and their biological significance; Classification of amino acids (Standard, Semi-standard, Non-standard; Proteinogenic, Non-proteinogenic; Essential, Non-essential; Polar, Non-polar). Physical properties (variations in structures, sizes, polarity, charges; resonance hybrid), optical properties (stereoisomerism; chirality; R- and S-; D- and L-; light absorption); and chemical properties (protonation/deprotonation; zwitterions; acid base properties, titration curve, pH and pKa, pI; reactivity of side chains) of amino acids, Amino acids as constituents of proteins, peptide bond. Uncommon amino acids and their functions.

**Unit – 2****(08 Hours)**

**Carbohydrates:** Introduction, classification and importance of carbohydrates. Monosaccharides - the structure of aldoses and ketoses; Optical properties of sugars: conformations of sugars, mutarotation, anomers, epimers and enantiomers; Chemical properties (Oxidation and reduction of sugars); reducing and non-reducing sugars; Glycosidic linkages (O- and N-type), formation of disaccharides (sucrose, maltose, lactose, trehalose), tri- and oligosaccharides (raffinose, rhamnose, and stachyose ) Polysaccharides: homo- and heteropolysaccharides, structural (cellulose and chitin) and storage polysaccharides (starch and glycogen); Role of glycoconjugates with examples - proteoglycans, glycoproteins and glycolipids; Carbohydrates as recognition molecules.

**Unit –3****(07 Hours)**

**Lipids:** Introduction, importance, and classification of lipids (simple, complex and derived lipid); Structure, properties, and classification of fatty acids (based on chain length and degree of unsaturation); Storage lipids- triacylglycerol and waxes. Structural lipids in membranes- glycerolipids, glycerophospholipids, galactolipids, ether-lipids, sphingolipids, and sterols; Importance of eicosanoids. Role of lipids as storage, signals, hormones, pigments, and in membranes.

**Unit – 4****(05 Hours)**

**Nucleic Acids:** Structure and properties of bases (purines and pyrimidines). Formation of nucleosides and nucleotides (phosphodiester and glycosidic bond); Nucleic acid structure: Watson-Crick model of DNA double helix, comparison of different forms of DNA (A, B and Z DNA); Structure and functions of major species of RNA (mRNA, tRNA and rRNA). Nucleic acid chemistry - UV absorption, the effect of acid and alkali on DNA; Biologically important nucleotides (source of energy, a component of coenzymes and second messengers)

**Unit – 5****(03 Hours)**

**Vitamins:** Active forms and major functions of water-soluble and fat-soluble vitamins; Major dietary sources, deficiency diseases, symptoms, and hypervitaminosis.

**PRACTICAL****(60 Hours)**

- 1) Laboratory safety and standards (precision, accuracy and sensitivity). Preparation of solutions (w/w, w/v, Molar, Normal)
- 2) Concept of buffer, buffering capacity and Henderson-Hasselbalch equation. Preparation of acetate buffer/phosphate buffer
- 3) Titration graph of acetic acid and Glycine.

- 4) Qualitative analysis of Amino acids (Ninhydrin, Xanthoproteic, Millon's, and lead acetate test)
- 5) Qualitative test for Carbohydrates: monosaccharides, disaccharides, and polysaccharides (Molisch, Fehling/ Benedict, Barfoed, Seliwanoff's, Osazone and Iodine test)
- 6) To determine the Iodine Number of oil/fat.
- 7) Qualitative test for Nucleic acid (Orcinol and DPA).

#### ESSENTIAL/RECOMMENDED READINGS

- 1) Nelson, D.L. and Cox, M.M. (2017). Lehninger: Principles of Biochemistry (7th ed.). W.H. Freeman & Company (New York), ISBN:13: 9781464126116 / ISBN:10-1464126119.
- 2) Berg, J. M., Tymoczko J. L. and Stryer L. (2011) 7th Edition. Biochemistry. New York, USA: W. H. Freeman and Co. ISBN-13: 978142927635.
- 3) An Introduction to Practical Biochemistry (1998) 3rd ed., Plummer D. T., Tata McGraw Hill Education Pvt. Ltd. (New Delhi), ISBN:13: 978-0-07-099487-4 / ISBN:10: 0-07-099487-0.

#### SUGGESTIVE READING:

- 1) Devlin, T.M., (2011). Textbook of Biochemistry with Clinical Correlations. 7th edition John Wiley & Sons, Inc. (New York). ISBN: 978-0-4710-28173-4.
- 2) Campbell, M.K. and Farrel, S.O. (2017). 9<sup>th</sup> Edition. Biochemistry. Boston, USA: Brooks/Cole Cengage Learning. ISBN-13: 978-1305961135

**Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

#### DISCIPLINE SPECIFIC CORE COURSE – 2 (DSC-2): Proteins

##### Credit distribution, Eligibility and Prerequisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Proteins	4	2	0	2	Class XII Science (Combination I: Chemistry + Biology/ Biological Studies/ Biotechnology/	NIL
DSC 2						

Biochemistry +  
Physics OR

Combination II:  
Chemistry +  
Biology/ Biological  
Studies/  
Biotechnology/  
Biochemistry +  
Mathematics)

### Learning Objectives

The course aims to introduce “proteins” and their importance to modern biochemistry, highlighting their structural features and unique characteristics that help them participate in every physiological process in life, thus also playing an important role in disease manifestation and their interventions.

### Learning Outcomes

After completion of the course, a student will

- Understand the diverse functions of proteins in a cell
- Understand the hierarchy of protein architecture – primary, secondary, tertiary & quaternary structure, with the ability to distinguish features of globular & fibrous proteins
- Be able to comprehend the fundamental mechanisms of protein folding and stability and their relation to conformational diseases
- Understand specialized proteins like structural proteins
- Gain comprehension of structure-function relationship of proteins and their significance in physiology, diseases and applications in industry and medicine.

## SYLLABUS OF DSC - 2

### THEORY

#### Unit – 1

(2 Hours)

**Introduction to proteins:** Introduction to peptides and proteins. Structural and functional diversity. Classification of proteins – simple and conjugated proteins; monomeric and multimeric proteins.

#### Unit – 2

(12 Hours)

**Hierarchy of protein structure organization:** Organization of protein structure into primary, secondary, tertiary and quaternary structures. Forces stabilizing the protein structure - covalent

(disulfide bridges) and non-covalent (electrostatic interactions and salt bridges, hydrophobic, hydrogen bonding, van der Waals). The peptide bond, dihedral angles  $\psi$  and  $\phi$ , helices, sheets, turns and loops, Ramachandran map. Motifs and domains. Structural proteins -  $\alpha$ -keratin, silk fibroin, collagen. Globular and fibrous proteins, membrane proteins.

#### **Unit – 3**

**(05 Hours)**

**Protein sequencing and Databases:** Sequencing techniques - N-terminal and C-terminal amino acid analysis, Edman degradation. Generation of overlap peptides using different enzymes and chemical reagents. Disulfide bonds and their location. Solid phase peptide synthesis. Protein databases – sequence and structure based.

#### **Unit – 4**

**(05 Hours)**

**Protein folding and conformational diseases:** Denaturation and renaturation of Ribonuclease A – discovery of protein folding. Introduction to thermodynamics of protein folding. Assisted folding by molecular chaperones, chaperonins and PDI. Diseases associated with protein misfolding – Alzheimer's and Creutzfeldt-Jakob disease.

#### **Unit – 4**

**(6 Hours)**

**Specialized proteins:** Transport protein: myoglobin and haemoglobin - Oxygen binding curves, influence of 2,3-BPG, CO<sub>2</sub> and H<sup>+</sup>; Cooperativity between subunits and models to explain the phenomena - concerted and sequential models. Haemoglobin disorders – Sickle cell anemia.

#### **PRACTICAL**

**(60 Hours)**

- 1) Scanning of proteins using UV-visible absorbance method
- 2) Solvent perturbation and denaturation studies of a protein
- 3) Estimation of proteins using Biuret method.
- 4) Estimation of proteins using Lowry/Bradford method.
- 5) Determination of isoelectric point of protein
- 6) Understanding protein sequence databases and homology modeling of proteins
- 7) Molecular Visualization Softwares: Pymol and Rasmol for protein structures from PDB

#### **ESSENTIAL/ RECOMMENDED READINGS**

- 1) Nelson, D.L., Cox, M.M. (2017). Lehninger: Principles of Biochemistry (7th ed.). New York, WH: Freeman and Company. ISBN13: 9781464126116, ISBN10: 1464126119
- 2) Schulz, G.E., Schirmer, R.H. (1979). Principles of protein structure. Springer, ISBN 978-1-4612-6137-7
- 3) Scopes, R.K. (1994) Protein Purification. Principles and Practice (3rd ed). Springer, ISBN 978-1-4737-2333-5

- 4) Stryer, L., Berg, J., Tymoczko, J., Gatto, G. (2019). Biochemistry (9th ed.). New York, WH:Freeman ISBN-13: 9781319114671
- 5) Voet, D., Voet, J.G. (2013) Biochemistry (4th ed.). New Jersey, John Wiley & Sons Asia Pvt. Ltd. ISBN : 978-1-11809244-6.

#### SUGGESTIVE READING:

- 1) Whitford, D. (2004). Protein Structure and function. Southern Gate, Chichester, West Sussex: John Wiley & Sons, Inc. ISBN-13: 978-047149894 ISBN-10: 0471498947.

**Note:** Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

#### DISCIPLINE SPECIFIC CORE COURSE- 3 (DSC-3): Biochemical Techniques

##### Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Biochemical Techniques DSC 3	4	2	0	2	Class XII Science (Combination I: Chemistry + Biology/ Biological Studies/ Biotechnology/ Biochemistry + Physics OR Combination II: Chemistry + Biology/ Biological Studies/ Biotechnology/ Biochemistry + Mathematics)	NIL

#### Learning Objectives

The objective of the course is to introduce various techniques to students that are used in a biochemistry lab. It will provide them an understanding of the principles underlying various

techniques. They will develop skills in the form of practical exercises and gain knowledge, which can be applied to pursue research and will be helpful in getting a suitable placement.

### **Learning Outcomes**

On successful completion of this course, the students will

- Acquire knowledge about the principles and applications of spectrophotometric and chromatographic techniques used in a biochemistry lab.
- Learn about the principle and applications of electrophoresis and centrifugation techniques.
- Will be able to identify biochemical techniques for separation and purification of biomolecules.
- Students will obtain hands-on experience to develop their experimental skills expected from any biochemistry student working in a research lab.

## **SYLLABUS OF DSC – 3**

### **THEORY**

#### **Unit – 1**

**(07 Hours)**

**Spectroscopic Technique:** Introduction to electromagnetic radiation. Principle of UV-visible absorption spectrophotometry. Working, instrumentation and applications of spectrophotometer, Lambert's law, Beer's law. Factors affecting UV-vis absorption, bathochromic shift and hypsochromic shift. Fluorescence spectrophotometry: Phenomena of fluorescence, stoke's shift, quantum yield, intrinsic and extrinsic fluors with example, working and applications of fluorimeter.

#### **Unit – 2**

**(06 Hours)**

**Centrifugation:** Principle of centrifugation, basics of sedimentation, svedberg unit, correlation of 'rpm' with 'g' value, factors affecting sedimentation (density, viscosity, size and shape). Types of rotors (fixed angle, vertical and swinging bucket rotors) and relevant applications. Differential centrifugation and density gradient centrifugation - zonal and isopycnic.

#### **Unit – 3**

**(09 Hours)**

**Chromatography:** Introduction to chromatography, Principle and applications of partition chromatography: Paper and thin layer chromatography. Concept of mobile phase, stationary phase, partition coefficient, retention factor, factors affecting separation. Types of partition chromatography: Ascending and descending chromatography. Methods of detecting separated samples.

Principle and applications of ion exchange, molecular sieve and affinity chromatography. Concept of distribution coefficient, types of matrix, mesh size, water regain value, packing of the column, void volume, elution volume, theoretical plates, exclusion limit and resolution. Factors affecting binding, elution and resolution. Methods of detecting eluted samples.

**Unit – 4****(08 Hours)**

**Electrophoresis:** Principle of electrophoresis. Factors affecting the mobility of molecules: Buffer, electrical field strength and charge. Types of electrophoresis: Polyacrylamide gel (native), SDS PAGE, isoelectric focusing and agarose gel electrophoresis. Continuous and discontinuous buffer systems in electrophoresis. Staining, detection, identification and molecular weight determination of molecules.

**PRACTICAL****(60 Hours)**

- 1) Determination of absorption maxima ( $\lambda_{\text{max}}$ ).
- 2) Verification of Beer's Law and calculation of molar extinction coefficient.
- 3) Preparation of cell free extract from a biological sample.
- 4) Separation and identification of amino acid acids by thin layer chromatography.
- 5) Separation of molecules by Ion-exchange chromatography.
- 6) Separation of molecules by gel filtration chromatography.
- 7) To perform PAGE (native) / SDS-PAGE.

**ESSENTIAL/RECOMMENDED READINGS**

- 1) Wilson, K. & Walker J (2010) Principles and Techniques of Biochemistry and Molecular Biology, (7th ed.), Cambridge University Press; ISBN 978-0-521-51635-8.
- 2) Boyer, R. F. (2012) Biochemistry Laboratory: Modern Theory and Techniques, (6th ed.), Boston, Mass: Prentice Hall; ISBN-13: 978-0136043027.
- 3) Sheehan, D. (2010). Physical biochemistry: Principles and applications (2nd ed.). Chichester: Wiley-Blackwell.
- 4) Plummer, D.T. (1998). An Introduction to Practical Biochemistry (3rd ed.), Tata McGraw Hill Education Pvt. Ltd. (New Delhi); ISBN: 13: 978-0-07-099487-4 / ISBN:10: 0-07-099487-0.

**SUGGESTIVE READING:**

- 1) Cooper, T.G. (2011). The Tools of Biochemistry (2nd ed.), Wiley-Interscience Publication (New Delhi); ISBN: 13:9788126530168.
- 2) Freifelder, D. (1982). Physical Biochemistry: Applications to Biochemistry and Molecular Biology, (2<sup>nd</sup> ed.), W.H. Freeman and Company (New York); ISBN:0-7167- 1315-2 / ISBN:0-7167-1444-2.

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