**Rashid Latif Medical College**

**Biochemistry Department**

**1st Year MBBS Session 2019**

**Learning Objectives**

1. **CELL BIOCHEMISTRY**

**Primary learning objectives**

1. To study the molecular and functional organization of cell and its subcellular organelles.
2. To study the membrane and its phenomena
3. To describe the methods to study cell biochemistry

**Secondary learning objectives**

**At the end of the topic the students should be able to**

1. Describe the importance of cell, and the types: Prokaryotic and eukaryotic cell.

2. Know the essential differences of a prokaryotic cell and eukaryotic cell.

3. Draw a diagram of eukaryotic cell showing different cell organelles.

4. Understand the following cellular organelles:

• Nucleus—its structure and functions.

• Mitochondrion, the power houseof a cell. Learn its structure and functions.

• Study endoplasmic reticulum, its types, structure and functions.

• Learn structure and functions of Golgi complexes.

• Study about lysosomes, their functions, inherited disorder—cell disease.

• Learn about peroxisomes: Their structure and functions.

• Study the structure and functions of cytoskeleton.

5. Understand the Membrane Phenomena

6. Describe the Transport of substances across the cell membrane including diffusion, facilitated and active transport

7. Understand the phenomena of Gibbs equilibrium, Osmosis, osmotic pressure

8. Learn membrane receptors and other catalytic molecules

9. Describe the principles and the methods to study cell biochemistry including centrifugation, RIA, ELISA, Chromatography, Electrophoresis, PH metry, Spectrophotometer

**2. Water, pH and Buffers**

1. Describe Ionization of water, weak acids and bases
2. Define PH and PH scale: Concept of PH and related topics (determination of PH), and concept of PI (isoelectric PH)
3. Define PKA value, dissociation constant (Ka), and titration curve of weak acids
4. Determination of PH of buffer: H-H equation and its applications (derivation not required)
5. Describe Body buffer systems (bicarbonate, ammonia, phosphate, and proteins and their mechanism of action

**3.CARBOHYDRATES**

**Primary learning objectives**

A. What are carbohydrates? Their general properties, isomerism, and biomedical importance.

B. List the monosaccharides of biological importance and learn their properties.

C.List the oligosaccharides and disaccharides of biological importance and learn their properties.

D. Study the chemistry and properties of various polysaccharides.

E. Study the chemistry and functions of proteoglycans.

**Secondary learning objectives**

**A.**

1. Define carbohydrates in chemical terms.

2. Classify carbohydrates into four major groups with examples of each group.

3. Describe the biomedical importance of carbohydrates.

4. Learn the general properties of carbohydrates with reference to glucose.

5. Describe isomerism and different types of isomers in carbohydrates.

**B.**

1. List and describe the monosaccharides of biological importance, viz. trioses, tetroses, pentoses, hexoses, etc. Example of bothaldoderivatives and ketoderivatives.

2. Study important properties of monosaccharides.

3. Study the sugar derivatives of biological importance.

• Deoxy sugars • Amino sugars • Amino sugar acids—Neuraminic acid • Glycosides—Learn the chemistry and biological/medical

importance, viz. cardiac glycosides, ouabain, phlorizin, etc. • Define “aglycone”.

**C.**

1. List the disaccharides of biological importance.

2. Study the chemistry and properties of three important disaccharides.

3. What are invert sugars and what is “inversion”? Learn about lactalose, a Keso disaccharide and its clinical importance.

4. Differentiate sucrose from either lactose or maltose.

5. Describe oligosaccharides, their combination with other macromolecules and their biomedical importance.

**D.**

Learn the chemistry and properties of polysaccharides of biological importance.

**a.**Homopolysaccharides (homoglycans)

1. Starch: Chemistry and properties. Differentiate between amylose and amylopectin (in tabular form)

2. Glycogen (animal starch)—Chemistry and properties.

3. Inulin—Chemistry and physiological importance.

4. Cellulose —‘Roughage’ value.

5. Dextrins and Dextran—Differentiate. Use of dextran as plasma expander.

**b.**Heteropolysaccharides (heteroglycans). Example—Mucopolysaccharides (glycosaminoglycans)

1. Sulphate free acid MPS—Hyaluronic acid and chondroitin

2. Sulphate containing MPS

• Chondroitin sulphate—A, B, C and D

• Keratan sulphate

• Heparin and Heparin sulphate

3. Neutral MPS—Blood group substances. Learn chemistry of each MPS, distribution in body, and its biological importance.Relation of MPS to mucopolysaccharidoses.

**E.** Learn chemistry and functions of proteoglycans.

**4.AMINO ACIDSAND PROTEINS**

**Primary Learning objectives**

A. To know what are proteins and their biomedical importance.

B. To learn what are amino acids, their classification structure, functions, and properties.

C. To learn the classification and properties of proteins.

D. Learn the structure of protein.

**Secondary Learning objectives**

**At the end of the topic the students should be able to**

**A.**

1. Define and classify proteins (biological functions, nutritional value, and overall shape of molecules)

2. Describe the biomedical importance of protein and learn composition of proteins.

3. Learn the physical and chemical properties of proteins.

4. Learn precipitation reaction of proteins and its application.

5. Learn the peptide linkage in a protein molecule and learn few biologically important peptides.

**B.Basic monomeric unit of protein: amino acid**

1. Define amino acids? Learn the basic structure of amino acid.

2. Classify amino acids.

3. Describe the general functions of amino acids.

4. Describe the physical and chemical properties of amino acids

5. Classification of standard (proteinogenic) amino acids (based upon side chain structure, polarity of side chain, nutritional, and metabolic end products), biologically importantnon-standard amino acids and their principal functions.

6. List essential amino acids, semi-essential amino acids and non-essential amino acids and why they are called so.

7. Understand dissociation and titration of amino acids

8. Determine of isoelectric pH of amino acids with two and three dissociable groups; importance of amino acids in the maintenance of pH

9. Understand the mechanism of buffering action of proteins

**C.**Structural organization of proteins.

1. Study the primary structure of protein.

2. Study the secondary structure of protein, linkages and types such as α-helix, β-pleated sheet structure, Triple helix, and Random coil.

3. Learn the tertiary structure, bonds involved in tertiary structure formation.

4. Learn the quaternary structure, bonds that make it and examples.

5. What is denaturation of protein? Learn various factors that cause denaturation, its application and the changes a protein molecule

undergoes after denaturation.

6. Describe protein misfolding (amyloidoses and prion disease)

**D.** Learn important techniques for separation of proteins including electrophoresis, isoelectric focusing, Chromatography, filtration, centrifugation and dialysis.

**E.**

1. Plasma Proteins, their biological functions along with clinical significance: pre-albumin, albumin, haptoglobin, ceruloplasmin, alpha-1-antitrypsisn, alph-2-macroglobulin and transferrin,

1. Classify immunoglobulins, their types, structure and biomedical significance.
2. Alpha fetoprotein and clinically important acute phase proteins (alpha-1 acid glycoprotein, c-reactive protein)
3. Ghycoprotein; components of glycoprotein (overview of linkages between protein and carbohydrates N-and O-linked oligosaccharides).
4. **NUCLEOTIDES AND NUCLEIC ACIDS**

**Primary Learning objectives**

1. Chemistry of purines, pyrimidines, their types and structure
2. Structure and functions of nucleotides and nucleosides (excluding metabolism)
3. Natural and synthetic derivatives of purines and pyrimidines and their biomedical role
4. Structure, functions and types of nucleic acids (excluding metabolism)

**Secondary Learning objectives**

**At the end of the topic the students should be able to**

**A.** 1. Study and list the different types of purine and pyrimidine bases that occur in a nucleotide.

2. Study and draw the purine nucleus and pyrimidine nucleus and number the positions of C and N atoms present in the nucleus.

3. Study the structure of two major purines and three major pyrimidines and also study their chemical names.

4. Define a ‘nucleoside’ and learn how a nucleoside is formed. Study the ‘glycosidic linkage’ by which the pentose sugar ribose/ordeoxyribose is linked to the purine and pyrimidine bases.

5. Study how a ‘nucleotide’ is formed by esterification of sugar molecule of nucleoside with phosphoric acid group. Study the possible

sites where the esterification with phosphoric acid can take place on the sugar molecule-ribose/ and deoxyribose.

6. Clearly now define a “nucleoside” and “nucleotide”. Differentiate the two in a tabular form.

7. Make a table naming the different types of nucleosides and nucleotides that can occur showing the respective bases/sugar/andphosphoric acid.

**B.** Study and list the various biologically important nucleosides and nucleotides present in tissues of human beings and study some oftheir important functions in the body.

• Study the synthetic derivatives. Certain synthetic nucleobases, nucleosides and nucleotides are widely used in the medical sciencesand in clinical medicine.

**C. Structure, function and types of nucleic acids**

* Study the two types of nucleic acids: Polydeoxyribonucleotides (DNA) and Polyribonucleotides (RNA).
* Learn about the phosphodiester linkage and DNA as the genetic material.
* Study in detail the structural characteristics of DNA“Watson and Crick Model of Double Helix”.
* Chargaff rules
* Study three types of DNA—B-DNA, A-DNA, Z-DNA.
* Draw a diagram of DNA double helical structure showing two strands and connections of bases.
* Study Dissociation and Reassociation of the double helical chain of DNA.
* Structure and functions of RNA
* Types of RNA with their biomedical role
* Learn the classes of RNA molecules
* Three different types of RNAs m-RNA, t-RNA and r-RNA.
* Study the salient features of structure of three RNAs and their functions.
1. **LIPIDS AND FATTY ACIDS**

**Primary Learning objectives**

1. Classification of lipids and their general biological functions
2. Fatty acids: definition, nomenclature, classification, chemical and physical properties, isomerism in fatty acids, role of saturated and unsaturated fatty acids in health and disease, role of trans fatty acids in coronary heart disease, omega-3 and omega-6 fatty acids and the importance of their dietary use.
3. Nutritionally essential fatty acids and their functions
4. Eicosanoids and their biological functions along with their significance in health and disease
5. Physical and chemical properties of fats and oils (triacyglycerols), saponification, iodine number and acid number of fats, rancidity of fats
6. Structure and biologic functions and significance of phospholipids, glycolipids, sulfolipids, and gangliosides
7. Lipid peroxidation and its significance

**Secondary Learning objectives**

**At the end of the topic the students should be able to**

**A.**

1. Define lipids. What are “Bloor’s’’ criteria to call a compound as lipid?

2. Classify lipids. Learn the three major groups with examples of each group.

3. Study the biomedical importance of lipids in general.

**B.**

1. List the derived lipids of biological importance.

2. Learn about fatty acid—definition and classification, isomerism, chemical and physical properties

3. Study nomenclature of fatty acids and isomerism in unsaturated fatty acids.

4. Study the role of unsaturated fatty acids in health and disease, role of trans fatty acids in coronary heart disease, omega-3 and omega-6 fatty acids and the importance of their dietary use.

5. Learn about essential fatty acids—their chemistry, functions and deficiency manifestations. Learn docosahexaenoic acid, (DHA)

3. Learn the chemistry, properties and biomedical importance of glycerol.

4. Learn about chemistry, properties, occurrence, distribution and biomedical importance of cholesterol.

5. Study other sterols of biological importance.

**C.**

1. List the simple lipids of biological importance

2.Study in detail the simple lipid triacylglycerol (TG) (neutral fat). Learn the chemistry and important physical and chemicalproperties of TG.

3. Learn how fats and oils can be identified: Saponification number, acid number, Iodine number.

**D.**

1. List the compound lipids of biological importance.

2. Study in detail about chemistry and functions of phospholipids.

• Define phospholipid. • Classify the various phospholipids • Learn the chemistry and properties of phospholipids

Study thevarious types of phospholipases and their site of action and products formed • Study the inherited disorder “Niemann-Pickdisease”

• Learn the functions of phospholipids and clinical importance of dipalmitoyl lecithin (DPL).

3. List important glycolipids of biological importance.

a. Study the chemistry, types and properties of cerebrosides. Learn about the inherited disorder “Gaucher’s disease”.

b. Study the chemistry, types and properties of gangliosides. Learn about the inherited disorder “Tay-Sach’s disease”.

4. Differentiate in a tabular form cerebrosides and gangliosides.

5. Study the chemistry of sulfatides and learn about inherited disorders metachromatic leukodystrophy, Fabry’s disease and Krabbe’s

disease.

**E.**

1. What are eicosanoids? Study the classification, chemistry, biosynthesis and catabolism of prostaglandins.

2. Study the important functions of PGs.

3. What are prostacyclins and thromboxanes, their important role in the thrombus formation? Study the chemistry and functions of leucotrienesand lipoxins

**F.** Lipid peroxidation and its significance.

1. **ENZYMES**

**Primary Learning objectives**

1. Introduction, classification and nomenclature of enzymes: Definitions of enzymes and IU of enzyme activity; Enzyme Commission Classification of enzymes along with main subclasses.
2. Properties of enzymes: chemical nature, active site, Catalytic efficiency, Specificity, Proenzymes, and Kinetic properties.Coenzymes and cofactors: Coenzymes derived from various vitamins along with the examples of enzymes requiring these coenzymes; and metal cofactors.Isozymes and their clinical significance.Allosteric enzymes and their biological significance.Factors affecting enzyme activity.
3. Types of enzyme inhibitors and their biomedical importance: Effects of competitive, non-competitive and uncompetitive inhibitors on enzyme activity effects of competitive and non-competitive inhibition on Lineweaver-Burke plot.
4. Mechanism of enzyme action and kinetics of enzyme activity (Michaelis-Menten and Lineweaver-Burke equations WITHOUT derivation).
5. Regulation of enzyme activity (covalent modification, allosteric regulation and regulation by gene induction, repression & de-repression of enzyme synthesis).
6. Therapeutic use of enzymes and diagnostic application of determination of enzyme activities of certain enzymes in plasma in hepatic, muscle, prostatic, pancreatic, bone and cardiac diseases.

**Secondary Learning objectives**

**At the end of the topic the students should be able to**

A. 1. Define enzyme.

2. What is meant by catalytic activity of enzymes?

3. Note that enzymes are protein in nature.

4. Learn what are coenzymes.

5. Study the role of metal ions in enzymes.

6. Study the nomenclature and classification of enzyme as approved by International Union of Biochemistry (IUB). Learn at least twoexamples from each class.

B. 1. Know what is enzyme catalyzed reaction and how an enzyme functions by lowering the energy of activation.

2. Define specificity of enzyme and learn different types of specificity.

3. Study Lock-and-Key theory and induced fit theory of mechanism of action of enzymes.

4. Learn various factors that affect the activity of enzyme, such as, pH, temperature, substrate concentration, enzyme concentration,product concentration, presence of inhibitors or activators.

5. Know the Michaelis-Menten equation and significance of each term.

6. Know the importance and application of double reciprocal or Lineweaver-Burk plot and calculate enzyme velocity when S >> Km, S = Km and S << Km.

C. Learn what is enzyme inhibition and various types of inhibition.

1. Nonspecific inhibition: List the various agents responsible for it.

2. Competitive inhibition.

3. Noncompetitive reversible inhibition, and noncompetitive irreversible inhibition.

4. Make a tabular form to show the difference between competitive and noncompetitive inhibition.

5. Learn examples of competitive inhibition in biological system: Clinically used drugs.

6. Study the various mechanisms by which enzyme activity is regulated, study allosteric enzyme.

D. Mechanism of enzyme action and kinetics of enzyme activity (Michaelis-Menten and Lineweaver-Burke equations WITHOUT derivation).

E. Regulation of enzyme activity (covalent modification, allosteric regulation and regulation by gene induction, repression & de-repression of enzyme synthesis).

F. Therapeutic use of enzymes and diagnostic application of determination of enzyme activities of certain enzymes in plasma in hepatic, muscle, prostatic, pancreatic, bone and cardiac diseases.

1. **Porphyrins and Hemoproteins**

**Primary Learning objectives**

1. Chemistry and biosynthesis of heme and other porphyrins including disorders of heme biosynthesis (Porphyrias).
2. Important hemoproteins foundin body along with their principal biologic functions; structure and function of hemoglobin and myoglobin, and types of hemoglobin, Hemoglobin A1c.
3. Oxygen binding capacity of hemoglobin, factors affecting and regulating the oxygen-binding capacity of hemoglobin. Methemoglobin (metHb) and methemoglobinemia.
4. Bilirubin Metabolism
5. Hyperbilirubinemias
6. Hemoglobinopathies

**Secondary Learning objectives**

**At the end of the topic the students should be able to**

1. Study the structure of Hemoglobin
2. Structure of heme
3. Structure of globin—the four polypeptide chains.
4. Different varieties of normal human Hb: Hb-A1, Hb-F, Hb-A2, Hb-A3 and embryonic Hb.
5. Differentiate Hb-A from Hb-F and • Study Hb-A1C (glycosylated Hb) and its clinical significance.

B. Study the properties of hemoglobin

1. Physical properties: Form and shape, size, molecular weight.

2. Chemical properties: Study the role of Hb in acid base balance.

3. Differentiate acid hematin from alkaline hematin.

4. Learn about the formation of following Hb derivatives, viz. formation of hemin crystal, hemochromogen, hematoporphyrin, hemopyrrole and hematoidin.

C. 1. Learn about methemoglobin and methemoglobinaemia, its formation, toxic effects and treatment. Learn how methemoglobincan be converted to Hb.

2. Study about methemalbumin and its clinical importance.

3. Learn about combination of Hb with various gases.

4. Combination with O2 to form oxyhemoglobin:

5. Learn how O2 combines with Hb and nature of the combination.

6. Study whatis ‘**heme-heme interaction’** and the **“hem-linked groups”**. • Study about two states of Hb: **‘R’ state** (relaxed) and **‘T’state** (taut/tense).

7. Combination with CO to form carboxy-Hb: • Learn how CO combines with Hb to form carboxy-Hb and how does it differ fromcombination with O2

8. Study CO-poisoning: Causes, clinical symptoms, chemical test to demonstrate carboxy-Hb, absorptionspectrum.

9. Combination with CO2 to form carbaminocompound.

10. Study about formation of sulfhemoglobin and its clinical significance.

11. Study about formation of cyanmethemoglobin, learn about clinical importance and biochemical basis of treatment of cyanidepoisoning.

12. Study the absorption spectra given by Hb and its derivatives.

D.Bilirubin Metabolism: Degradation of heme, synthesis, hepatic uptake, conjugation, and excretion of bilirubin and fate of bilirubin intestine.

E. Hyperbilirubinemias: Causes of hyperbilirubinemias along with the acquired and congenital disorders leading to hyperbilirubinemias; jaundice and kernicterus.

F. 1. Study the different abnormal hemoglobins and hemoglobinopathies

2. List the different types of abnormal hemoglobins produced by mutation in a gene, in a tabular form showing the replacement of asingle amino acid and its consequence in brief.

3. Study in detail about Hb-S and sickle-cell anemia. Learn the mechanism of “sickling” in Hb-S and its effects.

4. Study the different types of thalassemia, where the rate of synthesis of different chains is affected.

5. Study about α-chain thalassemia: (a) Hb-H, (b) Hb-Barts (c) Hb-Portland, Learn their clinical significance.

6. Study about β-chain thalassemia (thalassemia major): Salient clinical features and biochemical findings.

1. **Vitamins and Minerals**

**Primary Learning objectives**

1. General features of vitamins as essential nutrients.
2. Classification of vitamins according to their physicochemical nature and biochemical functions
3. Important dietary sources and recommended dietary allowances of vitamins.
4. Intestinal absorption, transport and storage of vitamins.
5. Mechanism of action of vitamins and their biochemical functions in body.
6. Disorders associated with vitamin deficiency and hypervitaminoses.
7. Minerals (Sodium, potassium, chloride, calcium, phosphorus, magnesium, and sulfur) and trace elements (iron, zinc, selenium, iodine, copper, chromium, manganese, cadmium and fluoride) in human nutrition and their sources, absorption, transport, storage, and biochemical functions along with their recommended dietary allowances (RDA).

**Secondary Learning objectives**

**At the end of the topic the students should be able to**

A. 1. Define and classify vitamins. There are four fat soluble vitamins A, D, E and K.

2. Study different forms of vitamin A, dietary sources and daily requirement.

3. Learn the various functions of vitamin A specially the visual cycle and deficiencymanifestations.

4. Study different forms of vitamin D and their synthesis specially calcitriol, the active form.

5. Learn the various functions of vitamin D and deficiency diseases.

6. Study different forms of tocopherols (vitamin E), its absorption and transport.

7. Learn the various functions specially antioxidant property of vitamin E and deficiency manifestations.

8. Study different forms of vitamin K, list the dietary sources and daily requirement.

9. Study various functions of vitamin K specially in coagulation process and its deficiencies.

B. There are two water-soluble vitamins—vitamin C and vitamin B complex groups.

1. Study the chemistry, dietary sources and absorption of vitamin

2. Learn the various metabolic functions and fate of vitamin C,specially its role in collagen synthesis.

3. Study deficiency manifestations of vitamin C.

4. List all the vitamin B complex constituents.

5. Study the chemistry and “biological active” coenzyme form of each one of them.

6. List the dietary sources, daily requirement of each.

7. Study the metabolic role of each one of them and the deficiency manifestations.

8. Many vitamins manifest certain symptoms in case of excess intake. List and study them.

C.Minerals: Sodium, potassium, chloride, calcium, phosphorus, magnesium, and sulfur) and trace elements (iron, zinc, selenium, iodine, copper, chromium, manganese, cadmium

1. **Nutrition**

**Primary Learning objectives**

1. Energy metabolism
2. Balanced diet
3. Proteins in nutrition
4. Fats and lipids in nutrition
5. Carbohydrates in human nutrition
6. Calculation of caloric requirement
7. Obesity and food additives

**Secondary Learning objectives**

**At the end of the topic the students should be able to**

1. Energy metabolism: Caloric value of food, Specific dynamic action (SDA) of food, respiratory quotient, metabolic rate (determination and factors affecting metabolic rate), basal metabolic rate (BMR) (measurement, calculation, and factors affecting BMR)basal metabolic rate (BMR) (measurement, calculation, and factors affecting BMR)
2. Balanced diet Definition and contents.
3. Proteins in nutrition: Obligatory nitrogen loss, nitrogen balance, nutritionally essential amino acids and their role in body growth and nitrogen equilibrium, determination of comparative nutritional efficiency and quality of dietary protein, recommended dietary allowance of protein, protein energy malnutrition (kwashiorkor and marasmus).
4. Fats and lipids in nutrition: Fats as a source of energy, role of saturated and unsaturated fats in health and disease, effect of dietary intake of trans-fats on health, and nutritionally essential fatty acids.
5. Carbohydrates in human nutrition: Protein sparing effect of carbohydrates, dietary carbohydrates and blood glucose along with the details of glycemic index, dietary fibers (types and biomedical importance).
6. Calculation of caloric requirement of a person and nutritional requirements in pregnancy, lactation, infancy, and old age.
7. Obesity and food additives (artificial sweeteners and flavor enhancers)
8. **The Extracellular Matrix**

**Primary Learning objectives**

1. Collagen
2. Elastin
3. Fibrillin-1 as a protein of microfibrills
4. Glycosaminoglycans (GAGs)
5. Structure and functions of proteoglycans

**Secondary Learning objectives**

**At the end of the topic the students should be able to**

1. Collagen: Types and structure of collagen; biosynthesis & degradation of collagen; collagenopathies (Ehlers-Danlos syndrome (EDS) and Osteogenesis imperfect (OI)).
2. Elastin: Structural characteristics of elastins; role of alpha 1-antitrypsin in elastin degradation; major biochemical differences between collagen and elastin; genetic disorders associated with elastin like Willians-Beuren syndrome, supravalvular aortic stenosis, pulmonary emphysema, and aging of the skin.
3. Fibrillin-1 as a protein of microfibrills; Marfan syndrome; fibronectin and its role in cell adhesion and migration; laminin as protein component of renal glomerular and other basal laminas.
4. Glycosaminoglycans (GAGs): Structure, classification, functions and distribution of GAGs; diseases associated with enzyme deficiencies of degradation of GAGs (mucopolysaccharidoses – syndrome & Hurler syndrome).
5. Structure and functions of proteoglycans.