**Rashid Latif Medical College**

**Biochemistry Department**

**1st Year BDS Session 2019**

**Learning Objectives**

**INTRODUCTION TO BIOCHEMISTRY & INTRACELLULAR/ EXTRACELLULAR COMMUNICATION**

**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 house of 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,

• 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. Learn membrane receptors and signalling mechanisms.

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

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**Learning Objectives**

**BIOCHEMISTRY OF BODY FLUIDS**

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
6. Concepts of acidosis , alkalosis and their types
7. Routes of transport across cell membrane including diffusion, facilitated and active transport, osmosis, osmotic pressure, surface tension, viscosity & their importance

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**Learning Objectives**

**CARBOHYDRATES**

**Primary learning objectives**

A. What are carbohydrates? Their general properties, 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.

**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.

**B.**

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

2. Study important properties of monosaccharides.

**C.**

1. List the disaccharides of biological importance.

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

3. 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

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**Learning Objectives**

**AMINO ACIDS, PEPTIDES AND 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.

E. Globular & fibrous proteins

F. Learn about heme and plasma proteins

**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.

1. Describe protein misfolding (amyloidoses and prion disease)
2. Study in detail about globular and fibrous proteins.

**D.**

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)

**E.**

1. Chemistry and biosynthesis of heme and other porphyrins including disorders of heme biosynthesis (Porphyrias).
2. Important hemoproteins found in 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

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**Learning Objectives**

**NUCLEOTIDES, NUCLEIC ACIDS and GENETICS**

**Primary Learning objectives**

1. Chemistry of purines, pyrimidines, their types and structure
2. Structure and functions of nucleotides and nucleosides (including metabolism)
3. Natural and synthetic derivatives of purines and pyrimidines and their biomedical role
4. Structure, functions and types of nucleic acids (including metabolism)
5. Replication, transcription, translation and recombinant DNA technology

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

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

Study nucleotide metabolism.

**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.
* 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. **Genetics**
2. To understand in detail the process of DNA replication and its importance.
3. To differentiate between prokaryotic and eukaryotic DNA replication.
4. To study DNA repair mechanisms
5. To learn the details of the process of transcription.
6. To understand post transcriptional modifications
7. To have an idea about reverse transcription
8. To study the genetic code and its characteristics.
9. To study in detail the process of translation (or protein biosynthesis) and their inhibitors.
10. To study gene expression in prokaryotes and in eukaryotes.
11. To explain the process and applications of recombinant DNA technology.

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**Learning Objectives**

**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

**Secondary Learning objectives**

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

**A.**

1. Define lipids.

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).

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

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

3. List important glycolipids of biological importance.

**E.**

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

2. Study the important functions of PGs.What are prostacyclins and thromboxanes, leucotrienes and lipoxins

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**Learning Objectives**

**ENZYMES**

**Primary Learning objectives**

1. Introduction, classification and nomenclature of enzymes
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.

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**Learning Objectives**

**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).

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**Learning Objectives**

**Bioenergetics and Biological Oxidation**

**Primary Learning objectives**

1. To understand the basic concepts of bioenergetics.
2. To describe the respiratory chain and oxidative phosphorylation.
3. To explain the mechanism of energy production by respiratory chain and oxidative phosphorylation.
4. To correlate the action of inhibitors and uncouplers at various sites of respiratory chain

**Secondary Learning objectives**

1. To get the concept of endergonic and exergonic reactions, free energy and free energy change.
2. To learn the terms redox potential and free energy and how they are related to biological oxidation.
3. To understand the term reducing equivalents and entery in electron transport chain (ETC)
4. To understand high energy compounds as carriers of energy including ATP
5. To describe substrate level phosphorylation
6. To define and study in detail the components and organization of mitochondrial electron transport chain.
7. To explain the reactions of electron transport chain, methods of electron transfer among the components of electron transport chain
8. To describe the energy release during electron transport chain.
9. To explain the structure of ATP synthase and mechanism of ATP synthesis
10. To define oxidative phosphorylation
11. To study chemiosmotic hypothesis of oxidative phosphorylation
12. To study inhibitors and uncouplers of electron transport chain and oxidative phosphorylation
13. To learn about mitochondrial shuttles.
14. To study inherited defects in oxidative phosphorylation

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**Learning Objectives**

**Carbohydrate metabolism**

**Primary Learning objectives**

1. To get the concept of different types of metabolic pathways (catabolic, anabolic, amphibolic)
2. To understand utilization of glucose in body and its various fates
3. To describe TCA cycle: A common and final pathway for breakdown of “Active acetate” obtained from carbohydrate, lipids and proteins to CO2 and H2O
4. To explain metabolism of Glycogen—to study formation of glycogen from glucose (glycogenesis) and its breakdown (glycogenolysis) and inherited disorders.
5. To describe other alternative pathways for oxidation of glucose — Hexose monophosphate pathway and Uronic acid pathway.
6. To describe formation of glucose from non-carbohydrate sources (gluconeogenesis).
7. To discuss regulation of blood sugar level:
   1. Autoregulation,
   2. Hormonal control,
8. To learn the normal blood glucose level and clinical significance of its variations.
9. To learn and describe diabetes mellitus and its types along with the metabolic changes in each type

**Secondary Learning objectives**

Glycolysis

1. To understand aerobic and anaerobic glycolysis
2. To describe in detail the reactions of aerobic and anaerobic glycolysis occurring in RBCs and other tissues.
3. To explain the regulatory mechanisms though which glycolysis is regulated, i.e, allosteric, covalent modification, hormonal etc.
4. To differentiate the role of hexokinase and glucokinase
5. To give the biomedical significance of glycolysis
6. To enlist the chemicals that inhibit a particular enzyme of this pathway and study their mechanism of action
7. To study Rapoport-Luebering shuntthat operates in RB Cells.
8. To learn the importance of 2,3-biphosphoglycerate (2,3-BPG) RBCs.
9. To learn the energetics (stoichiometry) of glycolysis-ATP formation in presence of O2 and in absence of O2.
10. To understand substrate-level phosphorylation and give examples from glycolytic pathway
11. To discuss lactic acidosis and genetic deficiency of pyruvate kinase.
12. To describe various metabolic fates of Pyruvate in detail

Oxidative decarboxylation of Pyruvic acid

1. To describe the enzymes, coenzymes and the reaction mechanism of pyruvate dehydrogenase complex
2. To correlate the mechanism of this enzyme complex with other similar acting enzyme complexes
3. To explain the deficiency of this enzyme along with the possible treatment

TCA cycle

1. To study the reactions of TCA cycle, enzymes and coenzymes required.
2. To study calculate the energy produced in TCA cycle
3. To identify the reactions which produce ATP at “Substrate level”
4. To describe the chemicals that inhibit particular enzyme.
5. To discuss how TCA cycle is regulated.
6. To explain why TCA cycle is called amphibolicin nature?
7. To define anaplerotic reactions and describe the anaplerotic reactions with reference to TCA

Gluconeogenesis

1. To define gluconeogenesis.
2. To enlist the non-carbohydrate sources or precursors i.e., amino acids, intermediates of TCA, glycerol, lactate and fatty acids
3. To describe their conversion into glucose.
4. To explain the significance of gluconeogenesis
5. To learn the reactions, enzymes and coenzymes required emphasizing the regulatory steps
6. To describe the regulation of gluconeogenesis
7. To discuss the biomedical significance of gluconeogenesis and role of gluconeogenesis in regulation of plasma glucose level.
8. To describe Cori cycle and glucose alanine cycle.

Glycogen Metabolism

Glycogen formation (glycogenesis):

1. To study the synthesis and importance of UDP glucose
2. Tolearn the reactions by which glucose is converted to glycogen, enzymes and coenzymes required for each step
3. To describe how glycogen synthesis is regulated by glycogen synthase

Glycogen breakdown (glycogenolysis):

1. To learn the reactions of glycogen breakdown with enzymes and coenzymes.
2. To study specially phosphorylaseenzyme, its active and inactive forms
3. To describe regulation of synthetic and catabolic pathway.
4. To emphasize on importance of allosteric regulation of glycogen phosphorylase by plasma glucose etc.
5. To study the difference in the regulation of glycogenolysis in liver and muscle
6. To study inherited disorders associated with glycogen synthesis/and breakdown (glycogen storage diseases)

Hexose monophosphate pathway (HMP):

1. To learn the synonyms.
2. To study the reactions involved in the pathway (oxidative and non oxidative phases), with enzymes and coenzymes involved.
3. To understand the significance of this pathway.
4. To describe Uses of NADPH in detail
5. To discuss glucose 6 phosphate dehydrogenase deficiency, its precipitating factors, its types with special emphasis on how it cause anemia

Regulation of Blood Glucose Level:

1. To know the normal level of blood glucose
2. To study the various factors which regulate the blood glucose level non hormonally.
3. To study the hormonal regulation ofblood glucose by insulin, glucagon, growth hormone, epinephrine and cortisol.
4. To describe the role of various metabolic pathways in blood glucose level regulation
5. To study the overview of hyperglycemia and hypoglycemia, their important causes and clinical manifestations
6. To study diabetes mellitus, its types along with its clinical manifestations.
7. To describe metabolic changes in type 1 and type 2 diabetes mellitus
8. To understand the recommendations for the diagnosis of diabetes mellitus and its treatment
9. To study glucose tolerance test and its interpretation

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**Learning Objectives**

**Lipid metabolism**

**Primary Learning objectives**

1. To learn the synthesis of Fatty acids
2. To study synthesis, storage and degradation of triacylglycerol
3. To study how fatty acids are oxidised in the body to give energy.
4. To learn how Ketone bodies are produced and utilised in the body.
5. To describe how cholesterol is metabolised in the body.
6. To study biosynthesis and fate of bile acids
7. To study synthesis and functions of eicosanoids
8. To describe the metabolism of phospholipids and sphingolipids
9. To study the chemistry and metabolism of lipoproteins and the clinical disorders associated with them.
10. To learn what is fatty liver and how it is formed?

**Secondary Learning objectives**

Fatty acid synthesis

1. To study de novo extramitochondrial FA synthesis
2. To note the starting material required in this synthesis and the product formed in this pathway.
3. To learn the production of cytosolic acetyl CoA and conversion of acetyl-CoA to malonyl-CoA, the enzyme and co-enzymes required for this reaction.
4. To list the sources of Acetyl-CoA in the cytosol.
5. To describe the regulation of fatty acid synthesis
6. To study in detail the multienzyme complex Fatty Acid Synthase system involved in de novo synthesis.
7. To learn in detail the various steps involved in de novo synthesis; the enzyme and co-enzymes required for the same.
8. To note the steps where NADPH is required and sources of supply of NADPH for this process.
9. To describe the process of elongation of fatty acid
10. To study the synthesis of polyunsaturated fatty acid

Triacylglycerol metabolism:

1. To study the synthesis and storage of triacylglycerol
2. To describe the reactions involved in synthesis
3. To enumerate and learn the sources of substrates required for the synthesis
4. To describe the process of breakdown of triacylglycerol (Lipolysis).
5. To note the products of lipolysis and study the fate of FA and glycerol after lipolysis
6. To study the enzymes involved in lipolysis: ‘Hormone sensitive’ ‘triacyl glycerol lipase’, “Hormone independent” diacyl glycerollipase and monoacyl glycerol lipase, and lipoprotein lipase.
7. To describe the regulation of lipolysis
8. Tostudy the adipose tissue metabolism in diabetes mellitus and in starvation.
9. Todescribe the influence of various hormones on adipose tissue

Oxidation of Fatty acids

1. To enumerate and list the various methods by which fatty acids are oxidised in body
2. To describe activation of fatty acids and translocation of fatty acids into mitochondrial matrix by carnitine shuttle.
3. To describe the sources of carnitine and its deficiency
4. To define beta oxidation.
5. To learn various reactions involved in beta oxidation with their enzymes and coenzymes required
6. To study the energy yield of beta oxidation in detail
7. To study the oxidation of unsaturated fatty acids
8. To describe the oxidation of odd chain fatty acids
9. To describe the oxidation of branched chain fatty acids (alpha oxidation)
10. To study omega oxidation of fatty acids
11. To study beta oxidation of very long chain fatty acids in peroxisomes
12. To describe the role of peroxisomes

Cholesterol metabolism:

1. To list the tissues in which cholesterol biosynthesis occurs.
2. To learn in detail the various steps in cholesterol biosynthesis, the enzymes and coenzymes required.
3. To identify the common steps of ketogenesis and cholesterol biosynthesis.
4. To study the formation of HMG CoA and learn its fates
5. To emphasize on the “rate-limiting” step in biosynthetic pathway and study how the cholesterol biosynthesis is regulated by various mechanisms
6. To study the various drugs which have been used to lower the blood cholesterol level and their mechanism of action
7. Todescribe the metabolic fate of cholesterol in the body.
8. To describethe formation of bile acids in the body and their functions.
9. To discuss the fate and their significance in health and disease.

Lipoproteins

1. To study how various lipoproteins are classified depending on hydrated density, electrophoretic mobility and apolipoproteins content
2. To learn the types of apoproteins present in various Lipoprotein fractions.
3. To study various type of lipoproteins: their structure, function, mechanisms of lipid transport
4. To discuss about atherosclerosis and the role of lipoproteins in atherosclerosis specially oxidized LDL
5. To learn the synthesis and metabolism of HDL
6. To learn the major functions of Lipoproteins in the body.
7. To study the clinical disorders associated with impairment of lipoprotein metabolism.

Eicosanoids

1. To explain the synthesis of eicosanoids (prostaglandins, thromboxanes, leukotrienes)
2. To study the regulation of synthesis of eicosanoids with emphasis on drugs involved.
3. To learn the functions and biomedical importance of eicosanoids

Metabolism of Phospholipids and Sphnigolipids

1. To study how different phospholipids can be synthesised from TG
2. To learn the synthesis of phospholipids (phosphatidylcholine, phosphotidyl inositol and phosphatidylethanolamine)
3. To study the synthesis of glycerol ether phospholipids (cardiolipin and platelet activating factor)
4. To describe the degradation of phospholipids
5. To discuss the effects of deficiency of lung surfactant
6. To describe the metabolism of glycolipids, biosynthesis of ceramide, sphingomyelin and gangliosides
7. To learn the degradation of sphingolipids
8. To describe sphingolipidosis

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**Learning Objectives**

**Protein Metabolism**

**Primary Learning objectives**

1. To understand the overview of “General amino acid pool” and utilization of amino acids.
2. To study interorgan amino acid exchange in normal post absorptive state
3. To study in detail degradation of amino acids
4. To learn the fate of ammonia and fate of carbon skeleton in the body

**Secondary Learning objectives**

1. To Study the concept of General amino acid pool and how it is formed?
2. To get the concept of protein turnover in human body.
3. To study nitrogen balance (positive and negative nitrogen balance).
4. To understand the utilization of amino acids by various tissues like brain, kidneys, liver, muscles during fasting and post absorptive state.
5. To study the mechanism of uptake of amino acids by various tissues: Role of pyrixodal-(P) and the hormones in the process.
6. To enlist essential, nonessential and semi essential amino acids

Dissimilation of amino acids (N-Catabolism of amino acids).

1. To study in detail the removal of nitrogen from amino acids by the following processes:
   1. To explain transamination and clinical importance of transaminases
   2. Oxidative and Non-oxidative deamination (enzymes and coenzymes required for the reaction)
   3. Transdeamination (enzyme and coenzymes required and its regulation)
2. To enlist the sources of ammonia
3. To study the transport of ammonia, and its fate.
4. To learn the reactions of urea cycle in detail along with its regulation
   1. To learn the normal level of blood urea, urinary urea, blood urea nitrogen and their clinical significance.
   2. To understand glucose alanine cycle
   3. To study briefly the metabolic disorders associated with urea cycle, inherited disorders
5. To study the formation of glutamine from ammonia in detail with enzymes and coenzymes
   1. To learn how glutamine is hydrolysed and in which tissues hydrolysis takes place
   2. To study the important functions of glutamine in the body.
6. To study the amination of α keto acids to form amino acid

**Integration and Regulation of Metabolic Pathways:**

Major Objectives

To understand various points at which various metabolic pathways of carbohydrates, proteins and lipids are interlinked and the significance ofthe same.

Specific Objectives

1. To study the interconversion of carbohydrates and lipids.
2. To study the details of conversion of fatty acids into amino acids.
3. To study the regulation and control of interconversions.
4. To learn the effects and metabolic changes associated with carbohydrate, protein and lipid metabolism in starvation

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**Learning Objectives**

**GIT**

**Primary Learning objectives**

1. To study introduction, chemical composition and secretion and regulation of various digestive juices of GIT such as saliva, gastric juice and HCl, pancreatic juice, bile and succus entericus
2. To understand hydrolysis (digestion) of carbohydrates, lipids, proteins, and nucleic acids in gastrointestinal tract
3. To learn the absorption of carbohydrates, lipids and amino acids
4. To learn about the diseases associated with GIT disorders like achlorhydria, peptic ulcers, lactose intolerance, cholelithiasis and pernicious anemia, celiac disease

**Secondary Learning objectives**

Digestion and Absorption of Carbohydrates

1. To study digestion of carbohydrates in mouth
2. To study the biochemical composition of saliva, with special stress to pH range, activating factors, and action of carbohydrate splitting enzymes which is α-amylase.
3. To learn the characteristics of α-amylase and its mode of action on starch, and glycogen and the products.
4. Digestion of carbohydrates in stomach (gastric digestion): To study the biochemical composition of gastric juice, with special stress to pH ranges and enzymes present.
5. To understand digestion of carbohydrates in duodenum and small intestine
6. To Study the composition of pancreatic juice and learn the role of carbohydrate splitting enzyme—pancreatic amylase
7. To list the carbohydrate splitting enzymes present in the intestine, make in tabular form their pH range of action, mode of action on substrate and products.
8. To study the site and rate of absorption of monosaccharides from GI tract.
9. To name process of absorption of sugars
   1. Simple diffusion
   2. Active transport
   3. Facilitated transport.
10. To learn in detail various mechanismsfortransport of various sugars, with special emphasis on **glucose transporters (GluT)**
11. To understand lactase deficiency in detail, with symptoms, biochemical cause and treatment

Digestion and Absorption of Lipids

1. To understand digestion of dietary lipids in mouth and stomach
2. To study the role of lingual lipase, and gastric lipase.
3. To study digestion in duodenum and small intestine
4. To study the role of “bile salts” in emulsification of fats. To learn the name and functions of bile salts
5. To study the lipolytic enzymes present in the pancreatic juice
6. To study the action of pancreatic lipase on TG (triacylglycerol) and what products are formed by hydrolysis of TG in intestinal lumen.
7. To learn the mechanism of absorption of the products of lipid digestion
8. To study in detail what happens to these hydrolytic products in intestinal epithelial cell after absorption from the gut lumen and how TG is again re-synthesised in intestinal epithelial cell.
9. To study the composition, size, formation, and fate of chylomicrons.
10. To learn what happens to dietary cholesterol and Phospholipids
11. To study the defects in digestion and absorption of lipids
    1. Steatorrhoea
    2. Chyluria
    3. Cholelethiasis

Digestion and Absorption of Amino Acids and Protein

1. To study the digestion of dietary proteins in stomach with special emphasis on the role of gastric juice
2. To learn the role of HCl in stomach, its synthesis and its deficiency
3. To understand the digestion of proteins in duodenum and small intestine
4. The role of pancreatic juice in digestion of proteins
5. To list and name the proteolytic enzymes present in intestinal juice, To study the nature of the enzymes, their mode of action, substrates for action and products formed.
6. To learn the site of absorption of amino acids and oligopeptides like tri- and dipeptides.
7. To study how the absorbed products are carried to Liver.
8. To study the diseases associated with protein digestion:
   1. Achlorhydria
   2. Peptic ulcer
   3. Celiac disease