**Rashid Latif Medical College**

**Biochemistry Department**

**M.B.B.S Second Professional Syllabus**

**Target Audience:** M.B.B.S Second Year Students

**Title:Bioenergetics and Biological Oxidation**

**Learning Objectives:**

Major 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

Specific 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. Toexplain 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. Tolearn about mitochondrial shuttles.
14. To study inherited defects in oxidative phosphorylation

Title: Carbohydrate Metabolism

**Learning Objectives**

Major 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 describeformation of glucose from non-carbohydrate sources (gluconeogenesis).
7. To explainmetabolism of other carbohydrates and inherited disorders associated with them.
   1. Metabolism of galactose
   2. Metabolism of fructose
   3. Metabolism of Lactose
8. To discussregulation of blood sugar level:
   1. Autoregulation,
   2. Hormonal control,
9. To learn the normal blood glucose level and clinical significance of its variations.
10. To learn and describe diabetes mellitus and its types along with the metabolic changes in each type

Specific 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

Uronic acid pathway:

1. Tolearn the reactions involved with enzymes and coenzymes required.
2. To study the biological importance of this pathway with special emphasize on glucuronic acid and its role in the body
3. To describe why vitamin C (ascorbic acid) can be synthesised by this pathway in lower animals, not in human beings?
4. To understand the connection of this pathway with HMP pathway

Metabolism of Galactose:

1. To learn the reactions involved in metabolism of galactose with name of enzymes and coenzymes.
2. Tostudy how lactose is synthesised in lactating mammary glands? (biosynthesis of lactose) and its regulation.
3. To describe inherited disorder associated with galactose metabolism (galactokisae deficiency and classic galactosemia)
4. To know the specific enzyme which is deficient and salient features of the disorder

Metabolism of Fructose:

1. Tolearn the different pathways of fructose metabolism with enzymes and coenzymes involved
2. To describe the pathway by which glucose is converted to fructose (sorbitol pathway)
3. To study the effect of hyperglycemia on sorbitol metabolism
4. To describe various inherited disorders associated with fructose metabolism (Essential fructosuria and hereditary fructose intolerance)
5. To know the specific enzyme deficient with the disorders andsalient features of the disorders

Ethanol metabolism

1. To study how ethanol is metabolized in the body through major and minor route
2. To learn the reaction involved in the metabolism
3. To study the drugs which can inhibit different reactions in ethanol metabolism
4. To understand the effects of ethanol on the body,
5. To describe how ethanol can cause fatty liver

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

**Topic: Lipid Metabolism**

Major 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?

Specific 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

Ketone bodies:

1. To learn what are ketone bodies?
2. To enumerate the ketone bodies.
3. To study the causes for ketone bodies formation and site of production of ketone bodies.
4. To learn the reactions of Ketone bodies formation in Liver (Ketogenesis), enzymes and co-enzymes required.
5. To describe how the ketone bodies are utilised by extrahepatic tissues (ketolysis).
6. To study the regulation of ketogenesis
7. To describe ketoacidosis and its causes

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 andlearn 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 classifieddepending on hydrated density, electrophoretic mobility and apolipoproteins content
2. Tolearn the types of apoproteins present in various Lipoprotein fractions.
3. To describe how chylomicrons and VLDL are synthesised in the intestinal mucosal cells and the liver cells respectively and secretedin the blood.
4. To describe the fate of Chylomicrons and VLDL
5. To emphasize on Lipoprotein lipase. Tostudy its location and its mode of action on chylomicrons and VLDL.
6. To study the interaction of circulating chylomicrons and VLDL with HDL.
7. To study the formation of LDL from VLDL via IDL.
8. To describe the formation of “chylomicrons remnants” and its fate.
9. Todescribe the metabolic fate of LDL.
10. To study the mechanism how LDL interacts with cell membrane, learn about LDL receptors and how it effects concentration of cellularcholesterol and its regulation.
11. To describe how LDL is destroyed in the body.
12. To discuss about atherosclerosis and the role of lipoproteins in atherosclerosis specially oxidized LDL
13. To learn the synthesis and metabolism of HDL
14. To learn the major functions of Lipoproteins in the body.
15. Tostudy the clinical disorders associated with impairment of lipoprotein metabolism.
16. To describe the role of Lp(a) in relation with atherosclerosis
17. To study the factors which tend to increase/and decrease the fat content of liver.
18. To learn the biochemical mechanisms by which the different types of fatty liver can be produced

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. Tostudy 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

**Topic: Protein Metabolism**

Major Learning Objectives

1. To understand the overview of “General amino acid pool” and utilisation 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
5. To study the decarboxylation reactions and the functions of various biogenic amines.
6. To understand the metabolic fate and metabolic role of aromatic amino acids, phenyl alanine and tyrosine and the inherited disorders associatedwith them.
7. To study the metabolic fate and metabolic role of sulphur containing amino acid and the inherited disorders associated with them.
8. To learn the metabolic role of other amino acids, like glycine, serine, histidine, tryptophan and other amino acids.
9. To study the conversion of amino acids to specialized products like, epinephrine, nor-epinephrine, creatine, histamine, GABA, serotonin, melatonin and melanin

Specific Objectives

1. To Study the concept of General amino acid poolandhow 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
7. To understand an overview of amphibolic intermediates formed from the carbon skeletons of amino acids.
8. To study about histamine, its formation, function and catabolism
9. To study the synthesis and role of gamma amino butyric acid
10. To study what are polyamines
11. To understand the conversion of phenylalanine to tyrosine, enzymes and coenzymes required.
12. To learn in detail the metabolic fate of tyrosine including formation of thyroid hormones, synthesis of catecholamines, and melanin, formation of tyramine,phenol and cresol.
13. To study the inherited disorders associated with phenyl alanine and tyrosine metabolism.
14. To study the synthesis and degradation of methionine and cysteine
15. To learn the metabolic role of cysteine and homocysteine.
16. To study what is glutathione, its synthesis and its important functions
17. To understand the inherited disorders associated with metabolism of S-containing amino acids, pin point the specific enzyme deficiency ineach and study the clinical features in brief.
18. To study briefly the metabolic role of Glycine and Serine
19. To learn the metabolic role of Histidine. How histamine is formed?
20. To understand the importance of histidine compounds like ergothioneine, Carnosine, Anserine
21. To learn the basis of “Figlu Test”
22. To study Histidinemia
23. To study Tryptophan metabolism
24. To study formation and functions of serotonin
25. To study briefly the inherited disorder “Hartnup’s disease”.
26. To study the metabolic role of other amino acids like Arginine, threonine, glutamic acid and aspartic acid, proline and hydroxyproline,lysine and branched chain amino acids, i.e., valine, leucine and isoleucine.
27. To study the biosynthesis of creatine and to learn the difference between creatine and creatinine
28. To learn the causes of creatinuria

**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

**GIT**

Major 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 succusentericus
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, cystic fibrosis and celiac disease
5. To study site of synthesis and major actions of gastrointestinal hormones like gastrin, cholecystokinin (CCK), secretin, gastric inhibitory peptide (GIP), vasoactive intestinal polypeptide (VIP), motilin, enkephalins, substance P, neurotensin and enteroglucagon.

Specific Objectives

Digestion and Absorption of Carbohydrates

1. To studydigestion of carbohydrates in mouth
2. To study the biochemical composition of saliva, with special stress to pH range, activating factors, and action of carbohydratesplitting 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 andenzymes 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 substrateand 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 understand the role of fat in stomach, delays the rate of emptying of stomach. What is the role of “enterogastrone”, a GI hormone?
4. To studydigestion in duodenum and small intestine
5. To study the role of “bile salts” in emulsification of fats. To learn the name and functions of bile salts
6. To revise your knowledge regarding composition of pancreatic juice and learn the role of secretin, ‘CCK-PZ’ and hepatocrinin-GIhormones.
7. To study the lipolytic enzymes present in the pancreatic juice
8. To study the action of pancreatic lipase on TG (triacyl glycerol) and what products are formed by hydrolysis of TG in intestinal lumen.
9. To understand the function of isomerase present in intestinal juice?
10. To learn the mechanism of absorption of the products of lipid digestion
11. To study in detail what happens to these hydrolytic products in intestinal epithelial cell after absorption from the gut lumen and how TGis again re-synthesised in intestinal epithelial cell.
12. To study the composition, size, formation, and fate of chylomicrons.
13. To learn what happens to dietary cholesterol and Phospholipids
14. 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, Tostudy 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. Hartnup disease
   4. Celiac disease

**Topic: Metabolism of Nucleotides**

Major Objectives

1. To learn the details of de novo pyrimidine synthesis, salvage and its catabolism.
2. To learn the details of de novo purine synthesis, salvage and its catabolism.
3. To studyvarious disorders associated with purine and pyrimidine metabolism.
4. To describe natural and synthetic derivatives of purines and pyrimidines and their role in health and disease.

Specific Objectives

Purines

1. To study all the steps of the purine biosynthesis.
2. Tostudy how AMP and GMP are further synthesised.
3. To understand how purine synthesis is regulated.
4. To study in detail ‘salvage pathways’ of purine bases.
5. To learn about LeschNyhan Syndrome and its relation to hyperuricemia
6. To study the formation of deoxypurines and its regulation
7. To explain the details of how guanosine and adenosine are catabolised to form uric acid, in liver and skeletal muscle.
8. To study in detail gout classification, clinical importance and treatment.
9. To study other inherited disorders of purine and pyrimidine metabolism like, adenosine deaminase deficiency, purine nucleoside phosphorylase deficiency and hyperuricemia

Pyrimidines

1. To learn indetailsthe reactions involved in pyrimidine synthesis.
2. Tolearn the intermediate steps with special reference to the role of PRPP.
3. To study how other derivatives of pyrimidine are synthesised.
4. To learn how deoxypyrimidine nucleotides are synthesised.
5. To study in detail how various pyrimidine nucleotides are catabolised.
6. To study the salvage pathway of pyrimidine synthesis.
7. To understand the natural and synthetic derivatives of purines and pyrimidines and their role in health and disease.

**Topic: Biochemical Genetics**

Major Objectives

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

Specific Objectives

Replication of DNA

1. To understand the structural basis of cellular information
2. To study the structural organization of DNA
3. To learn the structure and function of histone proteins
4. To define replication and its importance to living organisms.
5. To learn about semiconservative and conservative DNA replication
6. To list various enzymes and proteins that participate in DNA replication with their functions.
7. To describe briefly the sequential process of DNA replication
   1. Initiation: Define ori.
   2. Unwinding of DNA helix.
   3. To Clearly understand how ‘nick’ is formed, the enzymes that form and reseal it.
   4. To learn Polymerisation process.
   5. To understand how replication fork and replication bubbles are formed and the enzymatic machinery associated with it.
   6. To learn how the synthesis of primer takes place and its importance.
   7. To learn how the strands are joined together.
   8. To understand the relationship between cell cycle and replication.
8. To differentiate prokaryotic and eukaryotic DNA replication.
9. To study telomere and telomerase with reference to cancer and aging
10. To study different types of mutations and mutagens
11. To study about point mutation, i.e. transitions and transversions. Learn the effects with examples.
12. To study about frame shift mutations—deletion type and insertion type.
13. To learn the different mechanisms of DNA repair and emphasize in diseases associated with defects in DNA repair like xerodermapigmentosum.

Transcription

1. To define transcription (DNA-dependent RNA synthesis).
2. To study in detail RNA polymerase and its role in the process of transcription.
3. To learn various stages of transcription and various details associated with each stage.
   1. Formation of transcription complex
   2. Initiation
   3. Elongation
   4. Termination
4. To study post-transcriptional modifications of RNA.
5. To describe inhibitors of transcription.
6. To study reverse transcription in retroviruses and its relation to cancer and AIDS

Translation

1. To understand genetic code
2. To study in detail various characteristics of genetic code.
3. To enlist and study the materials required for protein biosynthesis.
4. To study the details of ribosomes and formation of aminoacyl tRNA.
5. To study the details of initiation, and various stages associated with it with special reference to initiation factors.
6. To study the details of the process of elongation and various stages in which it takes place with special reference to role of elongationfactors.
7. To study how the protein biosynthesis is terminated.
8. To learn about various antibiotics and other chemicals that inhibit the process of protein synthesis. Enumerate them and study their mechanism ofaction.
9. To learn about protein targeting

Regulation of gene expression

1. To study about gene expression in prokaryotes and in eukaryotes.
2. To study the types of gene expression.
3. To study about constitutive genes and inducible genes.
4. To learn in details about operon model specially ‘Lac’ operon.
5. To learn about repression and derepression of ‘Lac’ operon.
6. To study about the role of catabolite (gene) activator protein (CAP).
7. To learn in details the various modifications of gene expression in eukaryotes, i.e.,
   1. RNA processing
   2. Gene amplification
   3. Gene rearrangement
   4. Class switching and others.

Recombinanat DNA technology

1. To define recombinant DNA.
2. To understand restriction endonucleases andstudy their role in recombinant DNA technology.
3. To learn the details of cDNA synthesis.
4. To learn about plasmids. Study their characteristics and their role in recombinant DNA technology. Also to LEARN about other vectors, i.e. phagesand cosmids.
5. To study in detail how chimeric DNA molecule is produced.
6. To study the process of cloning.
7. To learn about gene library.
8. To understand different types of blotting techniques
9. To understand the process of hybridization and its applications
10. To Study restriction fragment length polymorphism and its applications
11. To study the process of polymerase chain reaction, and also its applications
12. To describe few applications of recombinant DNA technology.

**Biochemistry of Endocrine System**

Major Objectives

* + 1. To study hormones, their classification, their general characteristics and mechanism of action.
    2. To study the chemistry, mechanism of action, and metabolic role of various hormones secreted by various endocrine glands.

Specific Objectives

1. To give an overview of endocrine system
2. To define hormones
3. To classify hormones based on their mechanism of action and chemical nature
4. To understand the mechanism of action of each class of hormone
5. To give general characteristics of various types of hormone receptors
6. To learn about the types and actions of various kinds of G-proteins in mediating the action of hormones
7. To understand signal transduction pathways of various hormones
8. To learn types and role of various kinds of second messengers
9. Pituitary and hypothalamic hormones: structure, biosynthesis, secretion, transport, regulation, catabolism, and biologic actions of all hypothalamic and pituitary hormones, disorders associated with hyper- and hypo-activities of these hormones such as growth hormone deficiency (dwarfism), gigantism, acromegaly, Cushing’s syndrome, Addison’s disease, Diabetes insipidus and the inappropriate secretion of ADH (SIADH)
10. Thyroid Hormones: structure, biosynthesis, secretion, transport, regulation, catabolism, and biologic actions of all thyroid hormones, disorders associated with hyper- and hypo-activities of these hormones like goiter, hypothyroidism, hyperthyroidism, Graves’ disease
11. Calcium Regulating Hormones: structure, biosynthesis, secretion, transport, regulation, catabolism, and biologic actions of parathyroid hormone, disorders associated with hyper and hypo-activities of these hormones like role of parathyroid hormone, calcitriol, and calcitonin in calcium homeostasis, hypoparathyroidism, hyperparathyroidism (primary, secondary and tertiary), pseudohypoparathyroidism, rickets, and osteomalacia
12. Adrenal Cortical Hormones: structure, biosynthesis, secretion, transport, regulation, catabolism, and biologic actions of all adrenal cortical hormones, disorders associated with hyper- and hypo-activities of these hormones like Cushing’s disease/syndrome, secondary adrenal deficiency, Addison’s disease, primary aldosteronism and secondary aldosteronism
13. Adrenal medullary hormones: structure, biosynthesis, secretion, transport, regulation, catabolism, and biologic actions of all adrenal medullary hormones and disorders like pheochromocytoma
14. Male and Female Gonadal Hormones: structure, biosynthesis, secretion, transport, regulation, catabolism, and biologic actions of all male and female gonadal hormones, disorders associated with hyper- and hypo-activities of these hormones like, hypergonadism and hypogonadism in males and females
15. Hormones of pancreas: structure, biosynthesis, secretion, transport, regulation, catabolism, and biologic actions of all pancreatic hormones (insulin, glucagon, somatostatin, and pancreatic polypeptide), disorders associated with hyper- and hypo-activities of these hormones like pathophysiology of insulin deficiency and diabetes mellitus

**Metabolism of Xenobiotics and Cancer**

Major Objectives

* + 1. To learn about oncogenes, proto-oncogenes and tumor suppressor gene
    2. To learn about tumor markers and their importance
    3. To study important xenobiotics of clinical relevance
    4. To learn the details different phases of metabolism of xenobiotics
    5. To study responses to xenobiotics

Specific Objectives

Cancer

1. To study oncogenes and their role in carcinogenesis
2. To study the mechanism of action of oncogenes
3. To understand proto-oncogenes and mechanism of activation of proto-oncogenes
4. To learn about tumor suppressor gene and oncogenic viruses
5. To study important tumor markers and their clinical significance (Carcinoembryonic antigen, alpha fetoprotein, human chorionic gonadotrophin, calcitonin and prostatic acid phosphatase)

Xenobiotics

1. To define and classify important xenobiotics of medical relevance
2. To study the phases of metabolism and clinical significance
   1. Cytochrome P450, Cytochrome P450 hydroxylase cycle in microsomes, role of Cytochrome P450 in Phase I metabolism of xenobiotics, Induction of Cytochrome P450
   2. Phase II metabolism of xenobiotics, types of phase II reactions i.e. oxidation, reduction, hydrolysis, conjugation
   3. To define and learn various types of conjugation reactions
3. To study response to xenobiotics including pharmacologic, toxic, immunologic and carcinogenic effects

**Water and Electrolyte balance; Acid Base regulation**

Major Objectives

1. To learn the distribution of water and electrolytes in the body and their exchanges.
2. To learn the mechanism of normal water and electrolyte balance in health.
3. To study the regulatory mechanisms by which the water and electrolytes balance is maintained.
4. To study the abnormalities of water and electrolyte metabolism:
   1. Dehydration and
   2. Water intoxication.
5. To study pH, pK, acid, bases and body buffer systems, role of lung and kidney in maintenance of acid-base balance
6. To learn acid base disturbances like:
   1. Metabolic acidosis
   2. Respiratory acidosis
   3. Metabolic alkalosis
   4. Respiratory alkalosis

Specific Objectives

Water and Electrolytes

* + 1. To study the distribution of water in body compartments expressed as per cent of ‘lean’ body mass (fat-free mass).
    2. To study the electrolyte composition of ECF (plasma and tissue fluids) and ICF
    3. To study the movement or exchanges of water and electrolytes from one compartment to other in health.
    4. To study the various sources of Intake of water.
    5. To study the various processes by which water is lost from the body, i.e. output of water.
    6. To learn the various regulatory mechanisms that operate to maintain the homeostasis.
       1. Neural mechanisms: “thirst” mechanisms
       2. Humoral mechanisms i.e.
          1. Role of antidiuretic hormone (ADH)
          2. Role of aldosterone: The mineralocorticoid
    7. To study abnormalities of water and electrolyte metabolism can produce:
       1. dehydration
       2. water intoxication.
       3. Effect of pure water deprivation
    8. To study how the electrolyte balance is maintained in health (sodium, potassium, magnesium, chloride)

Acid Base Balance

* + - 1. To define pH andrevise your concept of pH and pK, Hasselbalch-Henderson equation.
      2. To study what are acids and bases with suitable examples. What is meant by strong acids/and bases and weak acids/and bases.
      3. To define buffer andstudy how a buffer acts in the body.
      4. To list the major sources of acids in the body which tend to decrease the pH.
      5. To learn the different mechanisms which regulate the pH of blood.
         1. Buffer systems in the body-first line of defense.
         2. Respiratory mechanisms, second line of defense
         3. Renal mechanisms-third line of defense.
      6. To explain buffer systems in the blood
         1. To list the various buffer systems in plasma and the erythrocytes.
         2. To study how the bicarbonate buffer system works andexplain how it is linked with respiration.
         3. To study how the phosphate buffersystem works and explain how it is linked with kidneys.
         4. To study how plasma proteins help in buffering action.
         5. To learn howhaemoglobin acts as a buffering agent.
      7. To understand the role of respiration in pH regulation.
      8. To study the renal mechanisms for regulation of pH of blood.
         1. Phosphate mechanism: Which operates in distal tubule.
         2. Ammonia mechanism: Which operates in distal tubular epithelial cells.
    1. To learn what is meant by anion gap and its significance.
    2. To Study the types of acid-base imbalances that can occur in human body.
       1. Acidosis, which can be ‘metabolic’ acidosis and/or “respiratory” acidosis.
       2. Alkalosis: Which canbe metabolic’ alkalosis and/or ‘respiratory’ alkalosis.
       3. To understand the “compensated phase” or “uncompensated phase” of acidosis and alkalosis