

# SYLLABUS - MEDICAL BIOCHEMISTRY FOR DENTISTRY

## **Biological oxidations**

Meaning of oxidations in living organisms. Principles of oxidation-reduction processes in the cell. Biologically important oxidation-reduction systems and their oxidation-reduction potentials.

Transport of electrons in inner mitochondrial membrane, production of proton gradient in mitochondria, terminal oxidation. Utilization of proton gradient in energy metabolism of the cell. Structure and function of ATPase in mitochondrial membrane, synthesis of ATP by the process of oxidative phosphorylation.

Characterization of oxidation-reduction systems in microsomes in the process of detoxification and desaturation in the liver. Hydroperoxidases in peroxisomes. Compartmentation of oxidation-reduction processes in the cell.

## **Synthesis of acetyl-CoA, Krebs cycle**

Transport of pyruvate into the mitochondria, synthesis of acetyl-CoA from pyruvate, characteristics of pyruvate dehydrogenase complex. Citrate cycle (Krebs cycle) mechanism of individual reactions. Energy yield of Krebs cycle. Meaning of Krebs cycle for energy metabolism of the cell. Regulation of Krebs cycle.

## **Energy-rich compounds**

Definition of energy-rich bond, types of energy-rich bonds, ways of formation of energy-rich compounds. Meaning of energy-rich compounds for the functions of the cell.

## **Transport through biological membranes**

Passive transport of compounds through biological membranes – simple diffusion and facilitated diffusion. Structures participating in facilitated diffusion. Active transport, types of active transport – primary and secondary active transport.  $\text{Na}^+$ ,  $\text{K}^+$ -dependent ATPase,  $\text{Ca}^{2+}$ -dependent ATPase. Transport of glucose in the intestine. Group translocation.

## **Metabolism of carbohydrates**

Sources of carbohydrates in the food, digestion and absorption of carbohydrates in alimentary tract.

Glycolysis – individual reactions of this metabolic pathway. Glycolysis in aerobic and in anaerobic conditions. Energy yield of glycolysis, phosphorylation at the substrate level. Regulation of glycolysis, metabolic and hormonal. Transport of reducing equivalent from cytosol into the mitochondria.

Glycogen – structure, synthesis and degradation. Regulation of glycogen metabolism. Gluconeogenesis, synthesis of glucose from non-carbohydrate sources (amino acids, lactate, glycerol), regulation of gluconeogenesis. Pentose phosphate pathway. Meaning of pentose phosphate pathway for synthesis of  $\text{NADPH}+\text{H}^+$  and pentoses. Synthesis and utilization of  $\text{NADPH}+\text{H}^+$ , Metabolism of fructose and galactose.

## **Regulation of carbohydrate metabolism in the organism**

Level of glucose in the blood (glycaemia) and its regulation. Glucose tolerance test – principle and meaning in diagnosis. Glycosuria – differential diagnostics. Defects of regulation of carbohydrate metabolism – metabolic characteristics and symptoms.

## **Metabolism of lipids**

Digestion of triacylglycerols and phospholipids in the intestine.

Metabolism of fatty acids in mitochondria -  $\beta$ -oxidation. Significance of  $\beta$ -oxidation for energy metabolism of the cell.

Synthesis of triacylglycerols and glycerolphospholipids. Synthesis of sphingosine and individual sphingolipids.

Synthesis of ketone bodies from acetyl-CoA, utilization of ketone bodies in the organism. Defects of ketone bodies metabolism.

Composition and synthesis of basic groups of lipoproteins and their changes during transport in the body. Transport of exogenous lipids. Role of liver in lipoprotein metabolism. Apoproteins and their role in metabolism of lipoproteins. Defects of lipoprotein metabolism – hyperlipoproteinaemias.

## **Metabolism of proteins and amino acids**

Intake of proteins by the food, nitrogen balance. Proteolysis in digestive tract and in the cells of the body. General reactions of amino acid metabolism, connection of essential and non-essential amino acids with intermediary metabolism. Decarboxylation of amino acids. Processes related to ammonia metabolism – transamination, deamination of amino acids – direct and indirect, fixation and transport of free ammonia. Synthesis of urea and its excretion. Interorgan relationships in amino acid metabolism – glucose-alanine cycle, specific characteristics of amino acid metabolism in different organs of the body. Synthesis of non-essential amino acids. Defect of metabolism related to changes in production and fixation of ammonia and other nitrogen containing compounds.

## **Metabolism of tetrapyrroles**

Synthesis of heme (synthesis of  $\delta$ -aminolevulinic acid and porphobilinogen, condensation of porphobilinogen, synthesis of uroporphyrinogens, synthesis of protoporphyrin). Regulation of heme synthesis. Hemoglobin – binding of oxygen to the hemoglobin, saturation kinetics. Degradation of heme.

## **Metabolism of nucleotides**

Synthesis of purine nucleotides de novo, formation of AMP and GMP from IMP. Metabolic regulation of purine nucleotide synthesis. Synthesis of pyrimidine nucleotides, formation of CTP. Regulation of pyrimidine nucleotide synthesis. Synthesis of nucleoside di- and tri-phosphates. Synthesis of deoxynucleotides and TMP. Degradation of purine and pyrimidine nucleotides. Salvage pathways of nucleotides synthesis.

Inhibition of nucleotide synthesis by antimetabolites, significance for therapy of cancer diseases.

Hyperuricaemia – biochemical mechanisms of the disease. Metabolic and renal hyperuricaemia, differential diagnosis.

## **Vitamins**

Roles of vitamins as essential factors of the food in metabolic processes. Coenzyme forms of vitamins. Role of vitamins in oxidation-reduction processes (NAD, FAD, FMN, NADP, vitamin C, antioxidants). Vitamins B<sub>1</sub>, B<sub>6</sub>, panthotenic acid, biotine, choline. Role of folic acid (p-aminobenzoate) and vitamin B<sub>12</sub> in transfer of one-carbon groups. Roles of fat soluble vitamins – A, D, E, K. Hypovitaminosis, avitaminosis and hypervitaminosis.

## **Biochemistry of gastrointestinal system**

Secretion of digestive juices – stomach, pancreas, bile. Digestion of basic components of food – proteins, lipids and carbohydrates. Absorption of foodstuffs, minerals and vitamins in small and large intestine. Gastrointestinal hormones and their role in regulation of gastrointestinal functions. Examination of the secretion of gastric juice.

## **Biochemistry of the liver**

Characteristics of metabolism of basic substrates in liver tissue (carbohydrates, lipids and proteins). Functional and metabolic heterogeneity of hepatocytes. Detoxification functions of the liver, mechanisms of detoxifications, transformation and conjugation phase of detoxification.

Synthesis of bilirubin and its metabolism. Hyperilirubinaemia, icterus (jaundice), types of jaundice and their causes.

Bile – its production and meaning.

## **Regulation of metabolism and physiologic processes**

Role of nervous system, endocrine systems and neuroendocrine system in regulatory processes (hypothalamus, pituitary gland and adrenal medulla). Signal molecules – hormones, neurotransmitters growth factors.

Receptors and mechanisms of the transfer of information from receptors into the cell. Ionic channels and their affection by mediators. G-proteins and their role, second messengers – cAMP, cGMP, inositolphosphate and diacylglycerol. Intracellular receptors and affection of gene expression.

Role of vegetative nervous system in regulatory processes. Sympathetic and parasympathetic nervous systems, structural relations, neurotransmitters, adrenergic and cholinergic receptors. Effects of sympathetic and parasympathetic stimulations on the contraction of smooth muscles.

## **Hormonal regulation**

Interrelations between CNS and endocrine system. Hypothalamic hormones, hormones of anterior pituitary and posterior pituitary, action of pituitary hormones. Hormones of individual endocrine glands and their roles. Hormones of adrenal cortex and adrenal medulla – glucocorticoids, mineralocorticoids, catecholamines. Hormones of pancreas – insulin and glucagon. Hormones of thyroid gland and parathyroid gland. Basal defects of these regulatory systems.

## **Internal environment of the organism**

Metabolism of water and minerals. Water – roles of water in the body, regulation of water equilibrium, hormones, osmoreceptors, osmotic active compounds and water. Osmotic, oncotic and hydrostatic pressure. Defects in water metabolism – hyperhydration, dehydration, edema.

Role of calcium ions, regulation of calcium content in extra and intracellular fluid.

Iron – meaning in the body, absorption, transport and its utilization. Regulation of iron metabolism.

Na<sup>+</sup>, K<sup>+</sup>, Cl<sup>-</sup> - roles in the organism, regulation, mineralocorticoids. Basic defects in metabolism of these minerals.

### **Acid-base balance**

Biochemical aspects of gas transport, regulation of homeostasis. Regulation of acid base balance – buffer systems, roles of respiratory system and kidney in regulation of acid – base balance. Basal defect of acid – base balance.

### **Roles of kidney in regulation of homeostasis and in excretion of waste products of metabolism**

Determination of creatinine and its meaning for examination of kidney functions – glomerular filtration rate, tubular absorption. Clearance of creatinine. Roles of kidney in regulation of acid-base balance, absorption and production of bicarbonate. Roles of kidney in regulation of blood pressure – renin-angiotensin system.

### **Nutrition and specific functions of organs in integration of metabolism**

Nutrition, food and its components. Energy substrates of the food. Differences between organs in utilization of energy sources. Metabolic and hormonal regulation of mobilization of energy sources. Utilization of energy sources in physical exercise, starvation and diabetes. Essential components of food – essential amino acids, vitamins, essential fatty acids. Mineral components of the food.

### **Biochemistry of the blood**

Blood plasma proteins and their roles. Red blood cell – basic metabolic characteristics. Meaning of glutathione for red blood cells. Transport of oxygen and CO<sub>2</sub>. Metabolism of iron in the body.

### **Introduction into pathobiochemistry and clinical biochemistry**

Biochemical parameters and their evaluation. Determination of enzyme activities in blood plasma and their meaning. Factors affecting enzyme activities in blood. Determination of isoenzymes and meaning. Example of changes of enzyme activities in the blood in myocardial damage. Utilization of biochemical parameters for evaluation of functions of organs and their defects.

### **Physiological levels of biochemical parameters in blood and their meaning for evaluation of metabolic defects and defects of the organism**

Enzymes: ALS, AST, CK, LD, ALP, GMT, amylase

Minerals: Na<sup>+</sup>, K<sup>+</sup>, Cl<sup>-</sup>, Mg<sup>2+</sup>, Fe<sup>2+</sup>, pCO<sub>2</sub>, HCO<sub>3</sub><sup>-</sup>

Organic compounds: urea, uric acid, triacylglycerols, cholesterol, creatinine, bilirubin – total and conjugated, total proteins, albumin, glucose

