

THE CONTENT OF EDUCATION OF THE SUBJECT „MEDICAL CHEMISTRY“ (study branch General Medicine) the 1st year, summer term, 2020-2021

1. WEEK

Lecture: Assoc. Prof. Ing. I. Žitňanová, PhD./ Assoc. Prof. PharmDr. V. Jakuš, CSc.
Dispersive systems in the relation to organism. Solutions, colloidal dispersive systems, heterodispersive systems, cell as a colloidal and heterodispersive system. Chemical reactions in biological systems. Kinetics of chemical and biochemical reactions. Redox-reactions in biological systems.

Seminar:

Organization of laboratory practices.
Condition for getting the credit from medical chemistry.

2. WEEK

Lecture: RNDr. L. Andrežalová, PhD./ Assoc. Prof. PharmDr. V. Jakuš, CSc.
Chemical composition of living systems. Biogenic elements.
Physiological functions of biogenic elements, free radicals, elements and their significant compounds from the toxicological viewpoint.

Seminar:

Physico-chemical methods – spectrophotometry. Separation methods - centrifugation

Practical exercise:

Determination of Fe²⁺ ions concentration in serum using analytical curve

3. WEEK

Lecture: RNDr. Z. Országhová, PhD. / Assoc. Prof. PharmDr. V. Jakuš, CSc.
Equilibrium of chemical and biochemical reactions. Protolytic (acid-basic) equilibrium in organism (in blood). Organism as thermodynamic system, energy sources, conversion and utilization of energy in living systems, significance and transmission of free energy in organism, entropy and biological system.

Seminar:

Classification of biogenic elements. Non-metallic and metallic biogenic elements - the function in organism and in biologically important compounds (enzymes). Biological importance of trace elements. Toxicity of chemical elements.
Free radicals.

Practical exercise:

Effect of metal ions on elimination of free radicals in biological material

4. WEEK

Lecture: Prof. Ing. Z. Ďuračková, PhD./ RNDr. Z. Országhová, PhD.

Structure and biochemically significant reactions of organic compounds I

Characteristics of structures and biochemically important reactions of bioorganic compounds.

Seminar:

Expression and calculation of the solution concentration. Colligative properties of solutions – osmosis and dialysis. Osmotic pressure – biological importance. The main ions of blood. Osmotic fragility of red blood cells. Calculating osmotic pressure, osmolarity and ionic strength of solution.

Practical exercise:

Preparation of solutions

Examination of hypotonic hemolysis (osmotic fragility) of erythrocytes

5. WEEK

Lecture: Prof. Ing. Z. Ďuračková, PhD./ RNDr. Z. Országhová, PhD.

Structure and biochemically significant reactions of organic compounds II

Relation between structure, properties and biological function of organic compounds, toxicologically important organic compounds.

Seminar:

The theory of acids and bases. Biochemical importance of protolytic reactions. „K“ and „pK“ values of weak acids and bases. „pH“ and its significance for the organism.

Buffers, their composition and effect. The capacity of buffers. Biochemically important buffer systems. Acid-bases equilibrium.

The principle of spectrophotometric and colorimetric measurement of pH. Calculation of pH of solutions of strong and weak acids, bases and buffers.

Practical exercise:

Determination of acidity constants of weak monobasic acids by titration

6. WEEK

Lecture: Prof. Ing. Z. Ďuračková, PhD./ Assoc. prof. RNDr. J. Muchová, PhD.

Structure, properties and biological functions of saccharides.

Biochemically important reactions of monosaccharides (oxidation-reduction, formation of important esters, amino saccharides, deoxy saccharides, ascorbic acid, glucuronic acid).

Polysaccharides, classification and structure.

Heteroglycans (mucopolysaccharides, glycoproteins, proteoglycans).

Seminar:

Organic compounds and their important reactions

Chemical properties of organic compounds, characteristic groups. Biochemically important reactions of alcohols, carbonyl compounds, carboxylic acids and their substitutional and functional derivatives. Organic acids in blood and urine.

Clinically important products of metabolism. Production of ketone bodies and urea.

Practical exercise:

Determination of urea concentration in serum and urine

7. WEEK

Lecture: Assoc. Prof. RNDr. J. Muchová, PhD./ Prof. Ing. Z. Ďuračková, PhD.

Structure and complex lipids and their derivatives

Structure of complex lipids. Glycerophospholipids, sphingophospholipids, ceramide, glycolipids – their biological function. Structure of biological membranes.

Arachidonic acid and their oxidative derivatives. Prostaglandins – structure and biological function.

Terpenes. Steroids

Seminar:

Saccharides.

Repetition of basic knowledge about saccharides, classification of saccharides. Monosaccharides (structure, optical activity), reactions of monosaccharides (oxidation, reduction, methylation, esterification, reaction with nonoxidative mineral acids). The origin of hemiacetals, detoxication function of glucuronic acid. Derivatives of monosaccharides and their biological importance. The formation of Schiff bases in nonenzymatic glycation of proteins. Glucose toxicity.

Oligosaccharides (disaccharides, glycosidic bond).

Polysaccharides (homopolysaccharides, heteropolysaccharides).

Practical exercise:

Enzymatic determination of glucose concentration in serum

8. WEEK

Lecture: Prof. Ing. Z. Ďuračková, PhD./Assoc. Prof. RNDr. J. Muchová, PhD.

Amino acids (AA) and peptides Biochemically important reactions of AA. AA as a buffer system.

Characteristics of peptide bond. Biologically important peptides and polypeptides (carnosine, anserine, glutathione, proteohormones, antibiotics, toxins).

Proteins. Colloidal character of proteins (electrical properties, isoelectric point, salting out, denaturation and biological function). Holoproteins – biological function.

Heteroproteins - their classification and characteristics of individual groups.

Structural proteins, proteins of the blood plasma, hemocoagulation system, fibronectin, complement system, inhibitors of proteinases. Immunoglobulins – structure and biological function.

Seminar:

Lipids

Repetition of lipids – their building units and structure. Physico-chemical properties of lipids and their participation in the construction and function of membranes. Lipoperoxidation of membranes.

Steroids - basic structure, nomenclature. Classification according to the functional importance and to the carbons number. Basic hydrocarbons of steroids (C₁₈ – C₂₉). Sterols. Provitamins and vitamins D.

Practical exercise:

Determination of concentration of total serum lipids

9. WEEK

Lecture: *Assoc. Prof. Ing. I. Žitňanová, PhD. /Assoc. Prof. RNDr. J. Muchová, PhD.*

Enzymology – introduction. General characterization of the enzymes

Mechanism of the effects of the enzymes – influence on the decrease of activation energy. The kinetics of the enzymes reaction. Active (catalytic) sites of the enzymes. The importance of the apoenzyme for the activity of the enzymes. The specificity and substrate effects of the enzymes. The influence of the basic factors on the activity of the enzymes. Significance of Michaelis (K_M) constant for the catalytic activity of the enzymes. Calculation and graphical evaluation of K_M constant.

Seminar:

Amino acids and proteins

Basic structure, chemical reactions of the amino acids (decarboxylation, deamination, transamination, acylation, reactions of the amino acid determination). Biologically important peptides. Structure and colloidal properties of the proteins.

Practical exercise:

Thin-layer chromatography separation of amino acids

Separation of hemoglobin from potassium hexacyanoferrate(III) by gel permeation chromatography.

10. WEEK

Lecture: *Assoc. Prof. Ing. I. Žitňanová, PhD. /Assoc. Prof. RNDr. J. Muchová, PhD.*

Activation and inhibition of the enzymes

Alteration of the proenzyme to the active enzyme. Inhibition - competitive, non-competitive, uncompetitive and allosteric. The allosteric enzymes – their regulation effects.

Induction and repression of the enzymes – their regulation function in metabolic processes in the cells. Enzyme nomenclature. Enzymes in medicine.

Seminar:

Factors that affect the activity of the enzymes. Calculation of the enzyme activities and K_M constant.

Practical exercise:

Effect of substrate concentration on enzymatic activity. Determination of Michaelis constant (K_M) of the lactate dehydrogenase (LDH)

11. WEEK

Lecture: *Prof. Ing. Z. Ďuračková, PhD./Assoc. Prof. RNDr. J. Muchová, PhD.*

Nucleotides and nucleic acids, nucleoproteins

Biologically important nucleotides. Oxidative stress. Free radicals, their physiological and pathological importance. Antioxidant systems in the organism.

Seminar:

Enzymes

Nomenclature of the enzymes. Specificity of the enzymes. Example of substrate and effect specificities. Different types of inhibition. Graphical expression of the enzyme inhibition.

Practical exercise:

Effect of activators and inhibitors on *arginase* activity

12. WEEK

Lecture: *Assoc. Prof. Ing. I. Žitňanová, PhD. /Assoc. Prof. RNDr. J. Muchová, PhD.*

Vitamins as a biologically important nutrient

Vitamins soluble in water. Vitamins soluble in lipids. Vitamins and their importance as coenzymes. Vitamins as part of nicotinamide and flavin coenzymes. Mechanism of their effects. Coenzymes transferring atom groups. Antivitamins.

Seminar:

Nucleic acids, mutagenic agents.

Basic building components and monomer units of nucleic acids, tautomers of purine and pyrimidine bases. Types of linkages in nucleosides, nucleotides, polynucleotides (N-glycosidic, phosphoester, phosphodiester), hydrogen bonds between complementary bases. Structure and functions of DNA and RNA. Physical and chemical modification of nitrogen bases – the role in point mutations.

13. and 14. WEEK

COMPENSATION OF ABSENCES AND TESTS.

The knowledge of the students will be checked on weekly base – via the tests in MS Forms during the seminar video meetings.

LITERATURE

Obligatory:

Országhová Z., Žitňanová I. et al.: Medical Chemistry. Vydavateľstvo UK, Bratislava, 2010, 272 s.

Országhová Z., Žitňanová I. et al.: Textbook of Medical Chemistry. Bratislava, 2018, 300 s. (electronic textbook)

Recommended:

Holum J.R.: Fundamentals of General, Organic and Biological Chemistry, 6th Edition, John Wiley and Sons Inc., New York, 1998

Protocols for laboratory practices:

Protocols will be provided via study group teams in MS Teams.