

THE CONTENT OF EDUCATION OF THE SUBJECT

„MEDICAL CHEMISTRY“ (study branch General Medicine)

the 1st year, summer term, 2025-2026

1st WEEK

Lecture: *Mgr. M. Dvořáková, PhD.*

Dispersive systems in the relation to organism

- Solutions
- Colloidal dispersive systems
- Crude-dispersive systems
- Cell as a colloidal and crude-dispersive system

Chemical reactions in biological systems

- Kinetics of chemical and biochemical reactions
- Redox-reactions in biological systems

Seminar:

Information about the study

- Filling out the evidence cards
- Conditions for acceptance of practical education from Medical Chemistry
- Organization of laboratory practices
- Principles of safety and security when working in a chemical laboratory
- Training in the laboratory practice (pipetting)

2nd WEEK

Lecture: *RNDr. Z. Országhová, PhD.*

Chemical equilibrium in living systems

- Equilibrium of chemical and biochemical reactions, Le Chatelier's principle

Acids, bases, pH, buffers, acid-base balance, maintenance of pH in blood

Organism as thermodynamic system

- Energy sources and energy conversion in biological systems
- The 1st and the 2nd laws thermodynamics
- Entropy and spontaneity of processes in biological system
- Significance and transmission of free energy in organism
- Energy rich compounds

Seminar:

Physico-chemical methods

- Physico-chemical methods used in the chemical and biochemical laboratory, spectrophotometry and its application in biochemistry - analytical and absorption curves, molar absorption coefficient
- Separation methods - centrifugation

Practical exercise:

Determination of Fe²⁺ ions concentration in serum using analytical curve

3rd WEEK

Lecture: *Prof. Ing. Z. Ďuračková, PhD.*

Structure and biochemically significant reactions of organic compounds I

- Relation between structure, properties and biological functions of organic compounds.
- Biochemically important reactions of bioorganic compounds.

Seminar:

Solutions

- Solutions characteristics (composition and properties)
- Osmotic efficiency of solutions, osmolarity of internal milieu
- Biological importance of osmotic and colloidally osmotic pressures
- Expression and calculation of the solution concentration, osmolarity, osmotic pressure and ionic strength of solutions

Practical exercise:

Preparation of solutions (demonstration)

Examination of hypotonic hemolysis (osmotic fragility) of erythrocytes

4th WEEK

Lecture: *RNDr. Z. Országhová, 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
- Homo- and heteropolysaccharides
- Glycoconjugates (glycoproteins, proteoglycans)

Seminar:

The theory of acids and bases, buffers

- 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 effects, the capacity of buffers, biochemically important buffer systems, acid-base balance

Calculation of pH of solutions of strong and weak acids, bases and buffers.

Practical exercise:

Acid-base balance disorders – case studies.

5th WEEK

Lecture: *Prof. Ing. Z. Ďuračková, PhD.*

Structure and biochemically significant reactions of organic compounds II

- Organic compounds important in metabolism
- Toxicologically important organic compounds

Seminar:**Saccharides.**

- Repetition of basic knowledge of saccharides, classification of saccharides. Monosaccharides (structure, optical activity),
- Reactions of monosaccharides (oxidation, reduction, methylation, esterification, reaction with nonoxidative mineral acids). The formation of hemiacetals, detoxification function of glucuronic acid.
- Derivatives of monosaccharides and their biological importance.
- 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. Detection of saccharides in urine

6th WEEK

Lecture: Assoc. Prof. RNDr. J. Muchová, PhD.

Structure and biological function of lipids and their derivatives

- Structure of complex lipids. The composition and properties of human fat. Glycerophospholipids, sphingophospholipids, ceramide, glycolipids – their biological function
- Structure of biological membranes.
- Arachidonic acid and its oxidative derivatives. Eicosanoids. Prostaglandins – structure and biological function. Thromboxanes, prostacyclins, leucotrienes. Importance in medicine.

Terpenes**Steroids****Seminar:****Biochemically important reactions of organic compounds**

- 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

7th WEEK (Monday-Wednesday)**8th WEEK** (Thursday-Friday)

Lecture: Prof. RNDr. J. Muchová, PhD.

Amino acids (AA) and peptides

- Structure and properties of AA, biochemically important reactions of AA, AA as a buffer system
- Characteristics of peptide bond and its influence on the proteins conformation
- 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 classes
- Structural proteins, proteins of the blood plasma, hemocoagulation system, fibronectin, complement system, inhibitors of proteinases.
- Immunoglobulins – structure and biological functions.

Seminar:

Lipids - simple and complex

- Characteristics of their structure
- Physico-chemical properties of lipids and their participation in the construction and function of biomembranes, lipoperoxidation of membranes.

Steroids

- Basic structure, nomenclature, their classification according to the functional importance as well as according to the number of carbon atoms
- Basic hydrocarbons of steroids (C₁₈ – C₂₉)
- Sterols
- Provitamins and vitamins D, bile acids, cholinic acid, steroid hormones

Terpens

Practical exercise:

Determination of concentration of total serum lipids

9th WEEK

Lecture: *RNDr. L. Andrežálová, PhD.*

Biogenic and toxic elements.

- Physiological functions of biogenic elements
- Free radicals
- Elements and their significant compounds from the toxicological viewpoint.

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 (TLC) separation of amino acids

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

10th WEEK

Lecture: *Assoc. Prof. Ing. I. Žitňanová, PhD.*

Enzymology – introduction. General characterization of the enzymes

- Mechanism of the enzymes action – influence on the decrease of activation energy, the kinetics of the enzymes reaction.
- Active (catalytic) site of the enzyme, 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:

Biogenic elements

- Classification of biogenic elements, structural forms of their occurrence in the organism
- Biological importance of biogenic elements, elements and their compounds from toxicology viewpoint
- the formation, properties and importance of free radicals in physiological and pathophysiological processes of the organism. Fenton and Haber-Weiss reactions, antioxidant systems.

Practical exercise:

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

11th WEEK

Lecture: Assoc. Prof. Ing. I. Žitňanová, PhD.

Activation and inhibition of the enzymes

- Different ways of enzyme activation
- Inhibition - competitive, non-competitive, uncompetitive and allosteric
- The allosteric enzymes – their regulation effects in the metabolism and function of the cell
- Induction and repression of the enzymes – their regulatory function in cellular metabolism

Enzyme classification and nomenclature (trivial, systematic)

Enzymes in medicine.

Seminar:

Enzymes I

- Factors that affect the activity of the enzymes
- Calculation of the enzyme activities
- Calculation and evaluation of K_M constant value, practical meaning

Practical exercise:

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

12th WEEK

Lecture: Assoc. Prof. Ing. I. Žitňanová, PhD.

Vitamins as a biologically important nutrients, coenzymes

- 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 hydrogen, electrons or atom groups
- Antivitamins.

Seminar:**Enzymes II**

- Specificity of the enzymes, examples of substrate and effect specificities
- Activation and inhibition of enzymes
- Different types of inhibition (competitive, noncompetitive, acompetitive, allosteric), examples in medicine
- Graphical expression of the enzyme inhibition

Practical exercise:

Effect of activators and inhibitors on *arginase* activity

13th WEEK

Lecture: Prof. RNDr. J. Muchová, PhD.

Nucleotides and nucleic acids, nucleoproteins

- Biologically important free nucleotides
- The structure and biological importance of DNA and RNA
- Mutations - chemical modification of heterocyclic (purine, pyrimidine) bases (oxidation, hydroxylation, alkylation), effect of physical mutagens

Oxidative stress

- its influence on the structure and function of biologically significant macromolecules
- the positive and negative role of free radicals in the organism
- antioxidant systems in the organism - their classification, function in protecting the organism from damage by reactive oxygen species

Seminar:**COMPENSATION OF ABSENCES AND TESTS.**

The knowledge of the students will be checked on weekly base.

STUDY LITERATURE**Obligatory:**

Országhová, Z., Žitňanová, I. et al. Textbook of Medical Chemistry [online]. Bratislava: Comenius University, 2018. 299 p. ISBN 978-80-223-4512-5.

https://zona.fmed.uniba.sk/uploads/media/Textbook_of_Medical_Chemistry_01.pdf

Recommended:

Harvey, R.A. and Ferrier, D. Lippincott's Illustrated Reviews: Biochemistry. 6th ed. J.B. Wolters Kluwer, Lippincott Williams & Wilkins, ©2013. 560 p. Lippincott Illustrated Reviews Series. ISBN 978-1-4511-7562-2

Protocols for laboratory practices:

Protocols will be provided on the web of institute