**Study program:** Integrative academic studies in Medicine

**Type and level of the study program:** Integrative academic studies

**Course title: Medical biochemistry and chemistry (M2-MB/CH)**

**Teacher:** Andrijević N. Ljiljana, Katanić N. Jasmina, Stankov M. Karmen, Ćebović N. Tatjana, Milić B. Nataša, Stojčević Maletić D. Jelena, Stanimirov G. Bojan, Sekeruš Z. Vanesa

**Course status:** Compulsory

**ECTS Credits: 16**

**Condition:** Human genetics

**Course aim** The aim of this course is to fit the students with biochemical knowledge necessary for studies of medicine, and to better understand the physiologic and pathologic processes in the organism. Also, an overview of basic biochemical tests used in clinical biochemistry as diagnostic tools will prepare the future physicians to use these tests properly and with understanding.

**Expected outcome of the course:** Knowledge about basic chemical constituents of the body. Knowledge about common biochemical pathways, bioenergetics, regulatory mechanisms and its importance for the normal metabolism. Knowledge about biological events on the molecular level and understanding of the essence of the diseases. Knowledge about specific biochemical processes occurring in several tissues and organs, and their importance for the function of the organism as a whole. Proper sampling of biologic material for biochemical tests. Evaluation of reliability and plausibility of several biochemical tests and their proper diagnostic use. The proper use of analytical methods and devices in biochemical laboratory, as so as their results in the diagnostic algorithm. Measuring units, normal and reference ranges of the results. Functional examination of metabolisms of several body components on the basis of their estimation in the biological samples. Proofing of the basic biochemical laws by laboratory methods.

**Course description**

*Theoretical education*

**Chemistry:** 1. Introduction to medical biochemistry and chemistry. Structure of matter. Periodic system of elements. Chemical bond. Coordination complexes and intermolecular forces. Dispersed systems. 2. Chemical kinetics. Chemical equilibrium. Classification of inorganic substances. Electrolytes and electrolytic dissociation. 3. Acids, bases and salts. Amphoteric electrolytes. Ionic product of water, pH and pOH. Acid-base equilibrium, hydrolysis of water. Buffer systems. 4. Colligative properties of solutions. Equilibrium in heterogeneous systems. Oxidoreductions and redox systems. 5. Introduction to organic chemistry. Hydrocarbons. Aromatic hydrocarbons. Alcohols. Phenols and ethers. Aldehydes and ketones. 6. Carboxylic acids. Substituted acids. Derivates of acids. Derivates of carbonic acid. Organic compounds containing nitrogen, sulphur and halogens. Heterocycles. **Medical Biochemistry:** 1. Introduction. Bioelements and biomolecules. Energy. Chemical reactions within cells. 2. Water as biological solvent and biomolecule. 3. Amino acids. Peptides. 4. Proteins – structure, physical and chemical properties, classification. 5. Fibrillary proteins – keratin and collagen, structure and function. 6. Haemoproteins – structure and function of haemoglobin and myoglobin, cytochromes, non-porphyrin metalloproteins. 7. Nucleic acids – general structure. Structure and properties of DNA. Structures, types and functions of RNA. 8. Carbohydrates – mono-, di- and oligosaccharides, polysaccharides, glycosaminoglycans. 9. Lipids – fatty acids, alcohols, simple and complex lipids, properties. Phospho-, glycero-, and sphingolipids; biological membranes. 10. Glyco-, lipo-, and phosphoproteins. 11. Enzymes – structure, properties, mechanism of catalysis, classification. Enzymatic reaction kinetics. Affecting factors, activation and inhibition. Isoenzymes, diagnostic importance of enzymes in practical medicine. Coenzymes and vitamins. 12. Bioenergetics – thermodynamics, exergonic and endergonic reactions. Energy rich chemical bonds. Biological oxidation. Electron transport system of mitochondria, ATP synthesis. 13. Metabolic pathways. Catabolism, anabolism. Regulation of metabolism. 14. Digestion and absorption of carbohydrates. Catabolism of carbohydrates – glycogen catabolism, glycogenolysis. Glycolysis: process, energy balance, regulation. Oxidative decarboxylation of pyruvate. The Krebs cycle of citric acid: process, energy balance, regulation. Pentose phosphate pathway – process and importance. Catabolism of other hexoses. Anabolism of carbohydrates – gluconeogenesis: process, energy balance, regulation. 15. Digestion and absorption of lipids. Lipoprotein metabolism. Catabolism of lipids – beta-oxidation od fatty acids, regulation. Catabolism of triglycerides, phospho-, and sphingolipids, cholesterol. Ketogenesis. Anabolism of lipids – biosynthesis of fatty acids: process and regulation. Biosynthesis of triglycerides, phospho-, and sphingolipids. Biosynthesis of cholesterol. 16. Digestion of proteins and absorption of amino acids. Metabolism of amino acids. Deamination, transamination. Ureogenesis. 17. Biosynthesis of nucleotides. Breakdown of nucleic acids. Biosynthesis of heme. 18. Molecular basis of heredity – DNA. Synthesis of DNA – replication. Synthesis of RNA – transcription. Synthesis of proteins – translation and processing. 19. Restrictive endonucleases. Vectors and cloning. Identification and isolation of genes (Blot). cDNA library. Polymerase chain reaction – PCR. 20. Cell cycle, oncogenes, growth factors, carcinogenesis. 21. Signaling molecules, mechanism of signal transduction. 22. Biochemistry of the eye. Biochemistry of nervous tissue – general metabolism, transduction of nerve impulses. 23. Water and electrolytes – distribution and metabolism of water, transport of electrolytes via the cell membrane, acid-base balance, mineral metabolism. 24. Biochemistry of the blood – blood plasma, blood clotting, biochemistry of red blood cell. 25. Biochemistry of connective tissue. 26. Central position of the liver, metabolism of glycogen, gluconeogenesis, ureagenesis. Metabolism of bilirubin, mechanisms of detoxification. 27. Hormones - classification, mechanism of action. Hormones of thyroid gland. Parathyroid hormone and D-hormone. Hormones of the adrenal medulla: adrenalin, noradrenalin, dopamine. Hormones of the pancreas. Hormones of the adrenal cortex: gluco-, and mineralocorticoids. Hormones of adeno- and neurohypophysis. Hormones of the gonads: oestrogens, progesterone, testosterone. 28. Prostaglandins, thromboxane and leukotrienes. 29. Biochemical basis of the immunological defence. 30. Molecular mechanisms of muscular contraction. 31. Biochemistry of the kidneys.

*Practical education: exercises, other forms of education, research related activities*

**Chemistry:** 1. Solutions. Chemical kinetics. 2. Basic types of non-organic compounds. Oxydoreductions. 3. Balances in electrolyte solutions. 4. Characteristic reactions of organic functional groups. **Medical biochemistry:** 1. Measurements in medical biochemistry –

review. Calculation of the reference values, precision and accuracy of measurement. Photometry – principles of the Lambert-Beer law. Absorbance (extinction) and molar extinction coefficient. Blank and the standard solution. Colorimeter and spectrophotometer. The absorption spectrum of bromothymol blue (BTB). Application of photometry. Colorimetric determination of bromothymol blue concentration via molar extinction coefficient. 2. Photometry – standard and construction of the calibration curve. Determination of the proportionality factor. Colorimetric determination of BTB concentration via standard solution and calibration curve. 3. Quantitative determination of blood plasma protein concentration – methodology review. Quantitative determination of blood plasma protein concentration using biuret test. 4. Serum protein fractions. Albumen/Globulin index. Plasma fibrinogen isolation using salting out method. 5. SEMINAR: Enzymology. Qualitative assessment of enzymatic activity of α-amylase from saliva. 6. Principles of quantitative determination of enzymatic activity. Determination of the initial reaction speed of p-nitrophenyl phosphate hydrolysis with alkaline phosphatase. Determination of the Michaelis constant of alkaline phosphatase for p-nitrophenylphosphate. 7. Determination of the molar extinction coefficient of NADH coenzyme. UV test. Measuring enzymatic activity via extinction change of NADH coenzyme (LDH, AST, ALT and CK) in serum. 8. Isoenzymes – definition, characteristics, diagnostic importance of isoenzyme profile. Demonstration of alkaline phosphatase isoenzymes. 9. SEMINAR: Vitamins and coenzymes. Quantitative determination of vitamin C in urine. 10. Metabolism of carbohydrates. Metabolism of glucose. Quantitative determination of blood glucose concentration – methodology review. Quantitative determination of blood glucose concentration using o-toluidine and GOD-PAP method. 11. Polarimetry – the principle of Biot law. The specific rotation. Determination of specific rotation of glucose. Quantitative determination of glucose in urine by polarimetry. 12. Metabolism of lipids. Metabolism of cholesterol and lipoproteins. Determination of triglycerides and HDL cholesterol - methodology review. Quantitative determination of plasma cholesterol and triglyceride levels by CHOD – PAP and GPO-PAP method, respectively. 13. Metabolism of proteins. Amino acid metabolism. Ureogenesis. Quantitative determination of urea in plasma using Berthelot method. 14. Metabolism of nucleic acid. The metabolism of purine and pyrimidine nucleotides. Quantitative determination of uric acid in plasma using alkaline phosphowolframate. 15. Quantitative determination of DNA using diphenylamine. Quantitative determination of RNA using orcinol. 16. SEMINAR: Molecular biology. Recombinant DNA technology. 17. Metabolism of minerals. Metabolism of sodium, potassium and chloride. Quantitative determination of chloride concentration in plasma. 18. Metabolism of minerals. Metabolism of calcium, magnesium and inorganic phosphate. Quantitative determination of total and ionic calcium and magnesium and inorganic phosphate in plasma. 19. Metabolism of minerals. Metabolism of iron. Biochemistry of blood. Metabolism of red blood cells and haemoglobin. Quantitative determination of iron and iron binding capacity in serum. Quantitative determination of haemoglobin. 20. Biochemistry of liver. Metabolism of bilirubin. Quantitative analyses of bile pigments. The significance of bile pigment metabolism. Qualitative determination of direct and indirect bilirubin in serum. Determination of bilirubin, urobilinogen and urobilin in urine. 21. Biochemistry of kidneys. Quantitative determination of creatinine using Jaffe's reaction. 22. Ion-exchange chromatography of amino acids.

**Literature**

*Compulsory*

1. Lieberman M, Marx A. Marks' Basic Medical Biochemistry – A Clinical Approach, 4th Edition. Wolters Kluwer Health, 2013.
2. Harvey R, Ferrier D. Lippincott's Illustrated Reviews: Biochemistry, 5th Edition. Wolters Kluwer Health, 2011.
3. Rodwell A, et al. Harper's Illustrated Biochemistry, 30th Edition. The McGraw-Hill Education, 2015.
4. Kovačević Z, Milošević Tošić M. Practical Biochemistry And Molecular Biology, Novi Sad, 2001.

| **Number of active classes** | | | | Other: |
|---|---|---|---|---|
| Lectures: 120 | Practice: 105 | Other types of teaching: - | Research related activities: - | - |

**Teaching methods** Oral presentations for small group of students using multi-medial didactic tools. Control of knowledge by the use of tests with multiple choice questions. Practical work in independent execution of biochemical tests and interpretation of the obtained results.

**Student activity assessment** (maximally 100 points)

| **Pre-exam activities** | **points** | **Final exam** | **points** |
|---|---|---|---|
| Lectures | 8 | Written | - |
| Practices | 12 | Practical | 5 |
| Colloquium | 50 | Oral | 25 |
| Essay | - | | |