

		<b>UNIVERSITY OF EAST SARAJEVO</b>					
		Faculty of Medicine					
		<b>Study program: Medicine in English</b>					
		Integrated academic studies		2nd study year			
<b>Full subject title</b>		MEDICAL BIOCHEMISTRY WITH CHEMISTRY					
<b>Department</b>		Department for biochemistry, Faculty of Medicine Foča					
<b>Subject code</b>			<b>Subject status</b>		<b>Semester</b>		<b>ECTS</b>
ME-02-1-013-3; ME-02-1-013-4			compulsory		III, IV		16
<b>Professor/ -s</b>		Full professor. Dijana Miric, PhD; full profesorDijana Miric,PhD; associate professor.Ilija Dragojevic, PhD; assistant professor Dragana Pavlović PhD;					
<b>Associate/ -s</b>		Assist. Sara Vukadinovic					
<b>Number of lectures/ teaching workload (per week)</b>			<b>Individual student workload (in hours per semester)</b>			<b>Coefficient of student workload S<sub>0</sub><sup>1</sup></b>	
<b>L</b>	<b>E</b>	<b>SP</b>	<b>L</b>	<b>E</b>	<b>SP</b>	<b>S<sub>0</sub></b>	
5	3	0	5 *15*1	3*15*1	0*15*1	1	
4	4	0	4*15*1	4*15*1	0*15*1	1	
total teaching workload (in hours, per semester) 5*15+3*15+0*15=120 4*15+4*15+0*15=120			total student workload (in hours, per semester) 5*15+1+3*15*1+0*15*1=120 4*15*1+4*15*1+0*15*1=120				
Total subject workload (teaching + student): 240+240=480 hours							
<b>Learning outcomes</b>		1. to determine the type of patient material 2. to apply the principles of rational use of laboratory methods 3. to master the skills of laboratory practice 4. to apply basic knowledge of chemistry and biochemistry in clinical medicine					
<b>General competences</b>		They possess broad fundamentals of theoretical knowledge and practical skills, preparing them for any type of postgraduate education as well as for collaboration with other medical professionals. They have adopted attitudes concerning medical ethics. They are prepared for further development and advances within the field of medicine. They are acquainted with methodology of scientific research. They have an unbiased attitude towards new scientific methods in medicine. They are conscious of the necessity for continuous learning and improvement process to maintain a high level of medical competence.					
<b>Preconditions</b>		Precondition for taking the exam: all year I exams passed					
<b>Teaching methods</b>		lectures, laboratory exercises, seminar papers					
<b>Subject content per week</b>		The primary goal of the course "Biochemistry with Chemistry" is to familiarize students with: a) the role of enzymes in catalyzing biological reactions and the mechanisms of regulating enzyme activity b) the metabolism of carbohydrates, lipids, and proteins c) the principles of eukaryotic genome organization and the details of information transfer from DNA to the level of functional protein d) the organization of the endocrine system, mechanisms, and effects of hormone action under physiological and pathological conditions e) the biochemical characteristics of individual tissues under physiological and pathological conditions. The chemistry curriculum is designed to focus on and explain those chemical concepts necessary for understanding and studying the complex problems of dynamic biochemistry through the study of selected areas of chemistry (general, inorganic, organic, and natural product chemistry). Chemistry classes are held in III (winter) semester. <b>Lectures:</b> 1. The importance of chemistry in medical sciences. Structure of the atom. Types of chemical bonds. Polarity of covalent bonds. Coordinate covalent bond. 2. Intermolecular bonds and the role of biomolecular interactions. The role of hydrogen bonds and dispersion forces among biologically important molecules. Water as a universal solvent.					

<sup>1</sup>Coefficient of student workload S<sub>0</sub> is calculated as it follows:

a) for the study programs not going through the licensing process: S<sub>0</sub> = (total workload in semester for all of the subjects 900 hrs – total teaching workload L+E in semester for all of the subjects 870 hrs)/ total teaching workload L+E in semester for all the subjects \_\_\_\_ hrs = \_\_\_\_\_. Consult form content and its explanation.  
b) for the study programs going through the licensing process, it is necessary to use form content and its explanation.

3. Dispersed systems – true and colloidal solutions and their role in the living world. Classification and properties. Thermodynamic changes during the dissolution of solid, liquid, and gaseous substances. Colligative properties of dilute solutions of non-electrolytes and electrolytes.
4. Chemical kinetics. Factors influencing the rate of chemical reactions. Chemical equilibrium.
5. Theories of acids and bases. Amphoterism. Dissociation constant. Degree of dissociation.
6. Electrolytic dissociation. Equilibria in aqueous solutions of electrolytes. Ion product of water. Concept of pH value.
7. Neutralization. Types of salts. Hydrolysis of salts.
8. Suppression of electrolytic dissociation – concept of buffers. Mechanism of action and buffer capacity. Biologically significant buffers.
9. Heterogeneous equilibrium – solubility product. Influence of factors on the solubility of sparingly soluble compounds.
10. Complex compounds – structure and biochemical significance.
11. Redox reactions. Oxidizing and reducing agents. Biological redox systems. Partial reduction of oxygen as a source of free radicals in living systems. Antioxidants.
12. Thermodynamic changes in chemical reactions in living systems. Biologically significant elements of the periodic table, toxicity of certain elements of the periodic table.
13. Structure of organic molecules. Isomerism of organic molecules. Classes of organic molecules. Mechanisms of organic reactions. Electronic effects (inductive, resonance) in organic molecules and their biological significance.
14. Reactivity of alkanes, alkenes, alkynes, alkadienes, aromatic compounds, heterocyclic compounds.
15. Reactivity of the hydroxyl group in alcohols and phenols. Reactivity of the carbonyl group in aldehydes and ketones.
16. Amino acids – properties, classification, and important reactions. Peptide bond. Structural levels of proteins – primary, secondary, tertiary, and quaternary structure. Properties and biologically significant proteins. Domains. Conformational changes in proteins – denaturation, renaturation.
17. General aspects of enzyme catalysis: the nature of chemical reactions in the cell, thermodynamic foundations of enzyme catalysis. Proteins as biological catalysts, organization of enzyme molecules, coenzymes, mechanisms of enzyme catalysis.
18. Nomenclature and classification of enzymes: enzyme structure, mechanism of enzyme action, formal aspects of enzyme kinetics (Michaelis-Menten kinetics), inhibitors and activators of enzyme activity, factors influencing the rate of enzyme-catalyzed reactions. Allosteric enzymes.
19. Regulation of enzyme activity and quantity in the cell: the significance of enzymes in medicine, diagnostically important enzymes.
20. Vitamins: general properties and classification; fat-soluble vitamins, water-soluble vitamins, vitamins as cofactors in metabolic processes. Metabolism and biochemical characteristics of vitamin action. Vitamins as cofactors in enzymatic reactions. Application of vitamins in medicine.
21. General aspects of metabolism: metabolic pathways, regulation and importance of regulation, intermediary metabolism, and substrates in metabolism. Ingestion of substances into the organism: digestion and transformation of carbohydrates, lipids, and proteins into forms that can be absorbed and enter metabolism.
22. Carbohydrates: stereochemistry and reactivity of monosaccharides. Reducing and non-reducing disaccharides. Polysaccharides. Glycosaminoglycans in medicine. Heterocyclic compounds in natural products.
23. Metabolism of carbohydrates: glycolysis, citric acid cycle (Krebs cycle), gluconeogenesis. Glycogen metabolism. Control of glycogen metabolism. Hexose monophosphate pathway. Energy aspects of carbohydrate metabolism.
24. Metabolism of fructose, lactose, galactose, glucuronic acid: specific pathways in carbohydrate metabolism. Complex sugars – glycoproteins and proteoglycans, regulation of carbohydrate metabolism.
25. Lipid metabolism: properties and roles of fats, structure of fatty acids. Fatty acid synthesis, fatty acid oxidation, fatty acid degradation. Ketone bodies. Energy aspects of fatty acid and ketone body metabolism. Synthesis of triacylglycerol.
26. Regulation of lipid metabolism: control of synthesis and degradation of triacylglycerol at the cellular and organism level. Cholesterol metabolism. Bile acids, arachidonic acid metabolism. Metabolism of complex fats. Metabolism of proteins and amino acids. General properties and

	<p>classification of amino acids. Biologically important peptides. Essential and non-essential amino acids. Structure and properties of proteins. General nitrogen turnover in the organism.</p> <p>27. Metabolism of proteins and amino acids: protein digestion and absorption of amino acids. Biomolecules as catalysts. Catabolism of amino acids, reactions of transamination, oxidative deamination and decarboxylation, urea synthesis. Metabolism of creatine and creatinine.</p> <p>28. Amino acid metabolism: essential and non-essential amino acids. Nitrogen metabolism originating from amino acids. Metabolism of glucogenic and ketogenic amino acids, special metabolism of individual amino acids.</p> <p>29. Convergence of metabolic pathways: origin of acetyl-CoA—carbohydrates, lipids, amino acids. Tricarboxylic acid cycle: cycle reactions, cycle energetics, cycle control, catabolic and anabolic aspects of the cycle.</p> <p>30. Energy production in the cell: bioenergetics and biological oxidations, gradual release of energy in biological oxidations, creation of reducing equivalents, oxidative phosphorylation. Short-term and long-term energy storage in the cell/organism (high-energy compounds, energy reserves—lipids, glycogen).</p> <p>31. Metabolism of hemoproteins: heme synthesis. Heme degradation and metabolism of bile pigments, disorders of bilirubin metabolism.</p> <p>32. Purine metabolism: structure and properties of purine bases and metabolism of purine nucleotides, key steps in synthesis.</p> <p>33. Pyrimidine metabolism: structure and properties of pyrimidine bases, pyrimidine base metabolism, precursor compounds in synthesis, salvage pathways in synthesis.</p> <p>34. DNA structure: spatial organization, mechanisms for maintaining spatial structure, chromatin organization in eukaryotic cells. RNA structure, spatial organization of RNA molecules, types of RNA, RNA synthesis, control of synthesis. DNA replication, molecular machinery for DNA replication, replication at DNA ends, repair of damaged DNA molecules, recombinant DNA.</p> <p>35. Protein synthesis and post-translational modifications: completion of protein synthesis, intracellular transport of proteins, intracellular degradation in lysosomes, ubiquitin and protein tagging for degradation, proteasomes.</p> <p>36. Biochemistry of hormones: endocrine system of the human organism, hormones, definition, classification based on the site of action (autocrine, paracrine, and endocrine action), classification based on chemical composition. Mechanism of action of water-soluble hormones, mechanism of action of fat-soluble hormones, receptors on cell membranes and within the cell, secondary and tertiary messengers.</p> <p>37. Organization of the endocrine system in humans: endocrine regulation at the level of the hypothalamus and pituitary: releasing factors. Metabolism and mechanism of action of hypothalamus and pituitary hormones.</p> <p>38. Metabolism and mechanism of action of thyroid hormones: metabolism and mechanism of action of hormones regulating calcium and phosphorus metabolism. Metabolism and mechanism of action of pancreatic hormones. Metabolism and mechanism of action of adrenal gland hormones. Metabolism and mechanism of action of sex hormones.</p> <p>39. Metabolism of inorganic salts (minerals): cation and anion turnover; trace elements, iron metabolism.</p> <p>40. Biochemical characteristics of tissues and body fluids: biochemistry of the liver, kidneys, urine, brain and nervous tissue, cerebrospinal fluid, muscle tissue.</p> <p>41. Biochemistry of blood: plasma proteins, plasma lipoproteins, blood coagulation, biochemical characteristics of blood cells.</p> <p><b>Exercises:</b></p> <ol style="list-style-type: none"> <li>1. Good laboratory practice, rules, and basic laboratory techniques: laboratory glassware and equipment.</li> <li>2. Separation of homogeneous and heterogeneous mixtures</li> <li>3. Dispersed systems: examples, thermal changes during dissolution, preparation of solutions with known concentration and known mass fraction. Mixing and diluting solutions.</li> <li>4. Colloidal solutions: properties and examples.</li> <li>5. Stoichiometric calculations: dispersed systems.</li> <li>6. Precipitation reactions, redox reactions, complexometric reactions</li> </ol>
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8. Preparation of buffer solutions, buffer capacity
9. Quantitative chemical analysis: volumetric methods.
10. Quantitative determination of biologically important ions
11. Qualitative detection of alcohols and phenols: esterification
12. Qualitative detection of aldehydes and ketones
13. Qualitative detection of amino acids and peptide bonds
14. Introduction to laboratory work and basics of spectrophotometry
15. Working with biological samples
16. Reduction reactions of carbohydrates: hydrolysis of sucrose
17. Hydrolysis of triglycerides: addition to unsaturated fatty acids. Quantitative determination of cholesterol and higher fatty acids
18. Qualitative detection of alcohols: esterification
19. Qualitative detection of amino acids and peptide bonds
20. General properties of enzymes. Acid non-enzymatic and enzymatic hydrolysis of starch. Testing of the conditions of the enzyme: the influence of the enzyme concentration, the concentration of the substrate, the temperature, the activator and the inhibitor, in the case of salivary amylase and urease from soya flour.
21. Determination of kinetic parameters ( $K_m$  and  $V_{max}$ ) of  $\beta$ -D-fructofuranosidase for sucrose. Determination of the concentration of reducing sugars by Folin -Wu method.
22. Enzymes in tissues and body fluids. Determination of amylase activity in serum and urine. Determination of serum alkaline phosphatase activity. Evidence of the presence of catalase in the blood.
23. Antioxidative cell capacity in defense against free radicals - non-enzymatic and enzymatic - determination of glutathione and catalase content
24. Vitamins. Proof of the presence of vit. A and D in fish oil. Reaction of copper acetate to niacin. Testing of oxidation-reduction ability of vitamin C.
25. Digestion of sugar. Enzymatic hydrolysis of starch by amylase saliva and identification of hydrolysis products. Fehling's test on mono-, di- and polysaccharides. Timol probe on glucose.
26. Determination of serum glucose by GOD-PAP method.
27. Digestion of proteins. The effect of pepsin and hydrochloric acid on digestion of proteins. Investigation of action of chymosin on casein milk. Biuret test. Molisch's test. Reaction of cysteine. Xanthoproteic reaction. Ninhydrin test.
28. Proteins in body fluids. Determination of total blood protein. Determination of the concentration of serum albumin.
29. Non-protein nitrogen compounds in body fluids. Determination of urea concentration in serum. Determination of serum creatinine.
30. Metabolism of fat and cholesterol. Alkaline hydrolysis of free fats. Demonstration of the presence of fatty acids in the hydrolyzate. Demonstration of the presence of unsaturated fatty acids in oil.
31. Metabolism of fat. Proving the effect of pancreatic lipase on the digestion of neutral fats. Determination of total serum cholesterol concentration.
32. Chromoproteids. Determination of blood hemoglobin concentration. Determination of the concentration of total and direct serum bilirubin (according to the Malloy-Evelyn method).
33. Coagulation. Determination of the overall concentration of calcium in serum. Determination of plasma fibrinogen concentration. Determination of plasma recalcification time. Indication of the effect of calcium ions on the formation of coagulum.
34. Blood biochemistry. Determination of the number of cellular blood elements.
35. Chlorides and serum buffers. Determination of serum chloride concentration. Determination of the concentration of inorganic phosphate in the serum. Testing serum buffer capacity and comparison with the deproteinized serum capacity and inorganic buffer mixture capacity. Determination of serum bicarbonate concentration.
36. Nucleoproteins. Acid hydrolysis of nucleoprotein. Demonstrate the presence of phosphoric acid in the hydrolyzate nukleoprotein. Demonstrate the presence of pentose in the nucleoprotein hydrolyzate. Prove the presence of purine bases in the nucleoprotein hydrolyzate.
37. Biochemical examination of urine. Specific urine density. Electrochemical reaction. Detection of reducing sugars in the urine. Proving the presence of inorganic phosphate in the urine.
38. Biochemical examination of urine. Proving the presence of calcium in the urine. Demonstration of the presence of urobilinogen and urobilin in the urine. Proving the presence of bilirubin in the urine. Free and bound sulphates in the urine. Demonstrating the presence of protein in the urine.

#### Compulsory literature

Author/s	Publication title, Publisher	Year	Pages (from-to)
Gopčević K et al	A Practical Guide to Chemistry excercises with	2016	,

	workbook and collection of numerical problems 5th ed. School of Medicine, University of Belgrade		
Lieberman M, Marks DA	Marks' Basic Medical Biochemistry: a clinical approach 4th ed. Lippincott Williams and Wilkins	2012	
Plješa-Ercegovac M, et al	Biochemistry laboratory practice-workbook. School of Medicine, University of Belgrade	2009	
Devlin MT	Textbook of Biochemistry with Clinical Correlations 7th ed. John Wiley and Sons	2010	
<b>Additional literature</b>			
<b>Author/s</b>	<b>Publication title, Publisher</b>	<b>Year</b>	<b>Pages (from-to)</b>
<b>Student responsibilities, types of student assessment and grading</b>	<b>Grading policy</b>		<b>Points</b>
	Pre-exam activities		<b>Percentage</b>
	lecture/exercise attendance	10	10%
	colloquium	20	20%
	working in laboratory/ lab. exercises	20	20%
	Final exam		
	practical test	10	10%
	written test	40	40%
	TOTAL	100	100 %
<b>Certification date</b>	June 17th 2024		

Responsible Person of the Faculty

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