Komisija za študijske zadeve
UL Medicinske fakultete

Univerza *v Ljubljani*
Medicinska fakulteta

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Course Regime

Course: CONCEPTS OF BIOCHEMISTRY

Study Programme: Dental medicine

Year of the Course: 1

Semester: Summer

Course type: Compulsory

Number of ECTS credits: 12

Lecturer(s): Damjana Rozman, Tea Lanišnik Rižner, Marko Goličnik, Jure Stojan

Participating Organisational Units (Departments and Institutes): Institute of Biochemistry

Parts (Modules) of the Course: /

Date of Issue: September 15th 2019

A. General part

1. Course objectives

Students learn about biomolecules in the human body, focusing on their structure, reactivity, and biochemical role. The objective of the course is to provide the student with knowledge about the basic properties of biomolecules resulting from their structure, and to relate it to the basic physicochemical laws (bioenergetics, kinetics, etc.) applicable in the living world. Students will become acquainted with the basic laws and mechanisms of biochemical events that form the basis for understanding the life processes in the human body, as well as methods for studying biomolecules.

2. Comprehensive outline of the course organisation

The course regime is prepared in accordance with the Regulations for the assessment of knowledge and skills for the united Master's Degree Programs in Medicine and Dental Medicine, adopted on 8 October 2018 (*regulations*).

The course Concepts of Biochemistry is scheduled in the summer semester. It is carried out by lecturers, teaching assistants and technicians in the form of lectures, seminars, laboratory courses and problem based learning / guided discussions (DOŠ).

Lectures are held two times per week in the Lecture hall 1 at the UL Faculty of Medicine, Korytkova 2:
Monday 8 – 10 AM
Friday 8 – 11 AM

DOŠ is organised in small groups in the Seminar rooms at the Institute for Biochemistry, Vrazov trg 2, for four (4) hours once per week, according to the published timetable. During DOŠ the topics from the lectures are discussed in more depth and as a preparation of students for the partial and final exams. The results of the partial exams are also discussed.

Seminars and laboratory courses are held in small groups at the Seminar rooms/Laboratories at the Institute for Biochemistry, Vrazov trg 2. **Seminars** are scheduled for four (4) hours per week, according to the published timetable. They include guided seminars and student seminars. The schedule for student seminars is published at the beginning of the semester. Each student must independently prepare and present one seminar. Accordingly, a student prepares a 20-minute oral presentation, which he or she performs using only a blackboard and pen. The student also prepares a half-page long written summary of the seminar, focusing on the structure and key thoughts of the presentation. The written summary is sent to the teacher for review one week before the seminar defence. The presentation of the seminar is followed by a discussion where the teacher, as well as colleagues in the group, ask questions.

Laboratory courses are scheduled for four (4) hours per week, according to the published timetable. Only students who are enrolled in the first year of studies can participate at the laboratory courses. The student should only participate at the course if he or she demonstrates an understanding of the theoretical basics and the experimental protocol of the exercise. All students must actively participate in the exercise. At the end of the tutorial, students write a report in the course syllabus book. Each laboratory course is completed if the student was sufficiently prepared for the laboratory exercise, actively participated in the exercise and the teaching assistant confirmed the report with the signature.

The attendance at the laboratory courses and seminars is compulsory and is checked by keeping the attendance list. The exception is warranted in the case of illness or similar, when appropriate certificate is provided. Students who are absent because of justifiable cause are allowed to substitute two missed

laboratory courses and seminars in an academic year. The student must defend the missed laboratory course or seminar at the next laboratory course, or latest at the last scheduled laboratory course. In the case the student has more then two justifiable absences, a formal request for permission to substitube the missing laboratory courses or seminars must be addressed to the head of the Institute of Biochemistry. The student will be notified on the further proceedings by e-mail, so the student's e-mail address should be included in the formal request.

Students, who were not allowed to participate in the laboratory course due to insufficient understanding of the exercise, may defend at most one exercise during the next laboratory course in an academic year.

When there is a valid reason, the student may participate at the seminar or the laboratory course as part of another group, if the teaching assistant of the other group agrees. The student must notify the other teaching assistant at least one week in advance over e-mail. The e-mail must contain the following information: the students group and the group in which he or she wishes to participate.

3. Description of on-going assessment of knowledge and skills

Testing understanding of laboratory courses and seminars
At the beginning of each laboratory course, a 10-minute written assessment of student's understanding of the theoretical basics and the experimental protocol of the current exercise are tested. The test is composed of two assignments; the first assignment is related to the understanding of the current laboratory exercise (literature: Temelji biokemije, laboratorijski praktikum), while the second assignment tests the chemical calculating, which is discussed at the seminars. Each assignment is scored with a maximum of 1 point, and the student must score at least half (1/2) points in both assignments. The final grade is descriptive: passed / failed. For the student to pass, he or she must collect at least 1 point, that is at least half (1/2) points in each assignment. Students who have not passed the test must demonstrate that they mastered the topic satisfactorily in discussion with the teaching assistant during the next practical course.

Students who failed the short assessment more than twice in a semester must take a composite written assessment, which includes the topic of all laboratory courses (5 questions) and all chemical calculating (5 questions). The written assessment is 50 minutes long, and is taken in a week after the last scheduled laboratory course and seminar.

Similarly, students who failed to complete all obligations regarding the laboratory courses and seminars until the last scheduled laboratory course must take the above mentioned composite written assessment.

Assessment of student seminars
The student seminar is graded with descriptive assessment: passed / failed. A student who has not passed the seminar can prepare a new seminar, but the seminar defence can only be taken during the scheduled seminar hours. A successfully defended seminar is one of the conditions for admission to the final examination.

4. Required conditions for the final examination (Course Exam)

The student can take the final exam when he or she has completed all requirements regarding the seminars and laboratory courses. Specifically, the student has completed all laboratory course requirements when he or she has performed all laboratory courses according to the program, has signed experimental reports for all laboratory exercises, has passed all written assessments or the composite assessment of student's understanding of laboratory courses and seminars. The student has completed all seminar requirements when he or she has successfully defended and discussed the student seminar.

5. Final assessment and examination of knowledge and skills (Course Exam)

The final exam is written and oral. The exam questions cover the topics of lectures, seminars, and DOŠ. Written examination comprises of 60 multiple choice questions and takes 90 minutes. Each question has only one correct answer, which is scored by 1 point. Unanswered question is scored with 0 points, wrong answer or selection of multiple answers (correct and incorrect) is scored with –0,2 points.

To pass the written exam the student must achieve 50,01%. The student has to pass the written exam to be admitted to the oral exam. In the case the students takes the exam for the third time, the student is admitted to the oral exam regardless of the score of the written exam.

The following score scale is relevant for the written exam:
- unsatisfactory (1-5), 0 - 50,00 %
- satisfactory (6), 50,01 - 60,00 %
- good (7), 60,01 - 70,00 %
- very good (8), 70,01 - 80,00 %
- very good (9), 80,01 - 90,00 %
- excellent (10), 90,01 – 100 %

Passing the final written exams with partial written exams:
The student can pass the final written exam by taking three (3) partial written exams during the semester according to Article 6 of the *regulations*, each consisting of 30 multiple-choice questions for which 45 minutes are allocated. There is no need to apply for partial written exams, while at the same time there are no alternative dates to take partial written exams. Students who achieve the composite score of at least 50,01 % with the written exams are admitted to the final oral exam without taking the final written exams. In addition, it is expected the student has completed all requirements regarding the seminars and laboratory courses to be admitted to the oral exam.

The grade for the final exam is determined at the oral exam. If the student fails the oral exam, he or she must again take the final written exam at another exam date.

The student who applies for the exam but then does not attend the exam for any reason is considered to have failed the exam.

Review of the written exams:
The short assessments written during the laboratory courses are discussed during the ongoing laboratory exercise. The partial written exams are discussed during DOŠ after the exam results are published. If the student wishes to review their own written exams, they have to arrange the viewing with the lecturer.

Improvement of the exam grade:
If a student passes the exam with a positive grade but wishes to improve the grade (in accordance with the *regulations*), he or she must retake the oral exam with the same examiner.

6. Other provisions

Examination regulations:
Students are obliged to observe ethical principles and the general rules of the examination regulations, set out in Article 34 of the *regulations*, during written or oral exams.

Before the exam, the student has to identify him/herself with the photo identification document. When taking any type of written exams or assessments, the student can only bring the pencil, rubber, a basic

calculator and an identification document. Silenced mobile phones and other electronic devices enabling taking pictures, as well as food, drinks and other personal belongings should be left in the student lockers or at the assigned spaces. During the exam, any communication between the students or any copying of the exam is forbidden. The students can start writing the exam only when allowed by the assigned lecturer or teaching assistant. Any type of exams and assessments can only be taken by the student him/herself and for any other arrangement both parties will be severely sanctioned. The students are obliged to leave all exam materials with the lecturer or teaching assistant immediately after finishing the exam.

Violation of the examination regulations:
The violation of the examination order is determined by the supervising lecturer or teaching assistant. In the event a student fails to follow examination regulations, described in Article 34 of the *regulation*, he or she shall be immediately prohibited from further examination in accordance with Articles 35 and 37 of the *regulation*. The exam shall be assessed unsatisfactory (5). Any unauthorized acquisition of exam materials by the students shall be considered as a disciplinary offense and sanctioned according to the Article 37 of the *regulation*.

Exam before the committee:
Exam before the committee is conducted in accordance with the *regulation*. It is composed of the written and oral part. When taking the exam for the fourth and fifth time, the student has to take the oral exam before a committee consisting of at least three members; an examiner and two members. In the case of the fifth examination, one member of the committee is from another department or institute of the Faculty of Medicine. For taking the fifth examination, a student must submit a formal written request to the Student Affairs Committee of the UL MF. In the case the request is approved, we highly advice the student to contact the course lecturer for consultations regarding the exam topics before applying for the exam.

7. Fundamental study material and Supplement reading

- Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry New York: Worth, last edition (P)
- Marks DB in sod., Basic Medical Biochemistry, A Clinical Approach, last edition (DOŠ), students receive the necessary material when attending the DOŠ
- Bavec A, Goličnik M, Lanišnik Rižner T, Makovec T, Rozman D. Temelji biokemije, laboratorijski praktikum, UL MF Ljubljana
  Bavec A, Goličnik M, Lanišnik Rižner T, Makovec T, Ravnik-Glavač M, Rozman D., Izbrana poglavja iz biokemije 1, UL MF Ljubljana

8. Exam topics, clinical presentations and skills

Exam topics	Subtopics	Courses and Readings
1. Molecular characteristics of living systems	1. Chemical and genomic evolution. 2. Characteristics of living systems. 3. Elemental composition of living organisms, major bioelements and bioelements in traces.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOŠ: Uvod v biokemijo
2. Structure of atoms and molecules, chemical bonds	1. Fundamentals of the atomic structure, intra-atomic interactions. 2. The structure of molecules. 3. Chemical bonds (strong and weak interactions); their importance in the maintenance of the structure and interactions of biological macromolecules.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Kemijske vezi ▪ DOŠ: Uvod v biokemijo
3. Water	1. Structure of water 2. Characteristics of water important for structure of macromolecules and the life; phase diagram. 3. Hydrogen bond, hydrophobic interactions. 4. Dissolution in water (groups of biomolecules and their orientation in hydophillic and hydrophobic environment). 5. Water as reagent.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Kemijske vezi ▪ DOŠ: Lastnosti vodnih raztopin
4. Solutions	1. Definition of solvent and solute. 2. Aqueous solutions of gases, liquids, solids and definitions of concentrations (molar fraction, molar, molar, percentage concentration). 3. Dissolution of gases in water (Henry's law). 4. Dissolution of gases in body fluids and disturbances due to changed external conditions. 5. Colligative properties of solutions; lowering of the vapour pressure of the solvent (Raoult's law), depression of the freezing point, elevation of the boiling point, osmosis and osmotic pressure, tonicity, Donnan equilibrium. 6. Solutions of the electrolyte, electrolyte dissociation. 7. Ionization of water, Kw, pH; biochemical / biological relevance of pH. 8. Acids and bases; strenght (dissociation rate, dissociation constant). 9. Neutralization of acids with bases et vice versa (titration curves, pH indicators). 10. Weak and strong electrolytes.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Koligativne lastnosti ▪ V: Kisline, baze in pufri ▪ DOŠ: Koligativne lastnosti, elektroliti. ▪ DOŠ: Elektroliti in protolitske reakcije

	11. Buffers; the definition of the buffer system, buffer capacity, the functioning of the buffer system. 12. Relevance of pH maintenance in cells / organism. Buffer systems in the organism (extracellular, intracellular). 13. Ionic strenght of solutions; the influence of electrolyte concentration on ionic strenght. 14. Salt solubility and solubility product; examples of salt formation/ crystals in the organism hydroxy- and fluoroapatite in bones and teeth).	
5. Thermodynamics	1. Work and heat as a form of energy. 2. First law of thermodynamics and enthalpy. 3. Energy changes in biochemical reactions. 4. Burnout and energy value of certain metabolic nutrients (carbohydrates, proteins). 5. Hess law. Enthalpy of chemical bonding. 6. Reversible / irreversible chemical reactions, entropy, second law of thermodynamics. 7. Equillibrium of chemical reactions, standard state, spontanous and non-spontanous processes free energy, chemical potentia. 8. Effects of various factors on the chemical euillibrium. 9. Coupled reactions, the importance for maintenance of life. 10. ATP (structre, hydrolisys, activation of biomolecules). 11. Other compounds with high phosphorylation potential (phosphoenol pyruvate, phosphocreatin).	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Kemijska termodinamika in kinetika ▪ DOŠ: Bioenergetika in kinetika v živih sistemih
6. Oxidoreductions	1. Oxidoreduction reactions; oxidoreduction couples, oxidation / reduction, oxidant / reducer. 2. Flow of electrons and change in free energy. 3. Standard state. Nernst equation. 4. Oxidoreduction reactions in organism, respiratory chain.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Oksidoredukcijske reakcije ▪ DOŠ: Oksidoredukcijske reakcije v živih sistemih
7. Chemical kinetics	1. The course of the chemical reaction against the equilibrium. 2. Energy profile of chemical and biochemical reactions. 3. Reaction rate and rate constant; determination of the rate constant. 4. Reaction order; determining the order of the reaction. 5. The influence of various factors on the reaction rate. 6. Catalysis, reaction mechanism, kinetics of catalyzed and non-catalyzed reactions.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Kemijska termodinamika in kinetika ▪ DOŠ: Bioenergetika in kinetika v živih sistemih
8. Transport of matter through biological membranes	1. Membrane permeability depending on the biochemical properties of the substance. 2. Thermodynamics of transport and transmembrane potential. 3. Direct and indirect transport. 4. Active transport: ATP hydrolysis and ionic gradient as the source of energy.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja

9. Carbon as the fundamental atom of biomolecules	1. Carbon atom; electronic configuration, resonance, steric properties. 2. Bonds between carbon atoms and between carbon and other atoms.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOŠ: Uvod v biokemijo
10. Biomolecules - general	1. Functional groups; structure, properties and characteristic reactions. 2. Interaction between functional groups (inductive, resonance and steric effects). 3. Isomerism; classes and biochemical significance. 4. Weak interactions between functional groups.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOŠ: Uvod v biokemijo
11. Aminoacids	1. Types of amino acids; structure, properties, nomenclature. 2. Nonstandard aminoacids. 3. Optical isomerism of aminoacids. 4. Aminoacids and pH; titration curves, isoionic and isoelectric points. 5. Typical reactions and separation.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Aminokisline ▪ DOŠ: Aminokisline in njihovi derivati
12. Peptides	1. Peptide bond; formation, strenght and properties. 2. Definition of peptides and the nomenclature. 3. Types of biologically active peptides and their significance. 4. Peptide hormones, structure and function of insuline. 5. Basics of peptide hormone activity at the molecular level.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOŠ: Aminokisline in peptidi
13. Biogenic amines	1. The formation and types of biogenic amines. 2. Structure and function of adrenaline. 3. The formation and structure of thyroid hormones.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOŠ: Aminokisline in njihovi derivati
14. Carbohydrates	1. Definition and distribution. 2. Monosaccharides aldoses and ketoses, representatives, structure and meaning. 3. Monosaccharide derivatives; amino-, acetyl-, alkyl- and sulfoderivatives 4. Optical isomery and mutarotation. 5. Glycoside bond, types and characteristics. 6. Characteristic reactions. 7. Disaccharides; types, properties and meaning. 8. Lactose and saccharose and intolerance. 9. Oligosaccharides. 10. Biochemical concepts of blood groups (AB0 system). 11. Polysaccharides: monoglycane, heteroglycans. 12. Starch, structure, biochemical meaning. 13. Structural polysaccharides; cellulose, chitin, glukosaminglycans. 14. Hydrolysis of glycoside bonds by polysaccharides. 15. Bacterial cell wall; structure, biochemical stability.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Ogljikovi hidrati ▪ DOŠ: Ogljikovi hidrati in njihovi derivati

	16. Structural characteristics of glycoproteins.	
15. Lipids	1. Fatty acids; classification, characteristics and function. 2. Triacylglycerols; structure and function. 3. Glycerophospholipids; classification, structure and function. 4. Sphingolipids; classification, structure and function. 5. Biological membrane; biochemical aspects,structure and function. 6. Building blocks of lipids as signaling molecules; unnsaturated fatty acids, phosphoinositides. 7. Eikosanoids (prostaglandins, prostacyclins, tromboxanes and leukotrines) structure and function. 8. Lipid transport in aqueous media, emulgation, micelles, lyposomes, lipoptoreins. 9. Steroids; structure, clasification, stereochemistry and nomenclature. 10. Cholesterol: structure and function. 11. Bile acids; classification, structure and function. 12. Steroid hormones; structure and function of corticosteroids and sex hormones. 13. Structural basis of steroid hormone action. 14. Lipid soluble vitamins; general characteristics. 15. Structure and function of vitamin A. Role in visual cycle. 16. Structure and function of vitamins D, E and K. 17. Biochemical aspects of hyper and hypo-vitaminoses.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Lipidi ▪ DOŠ: Lipidi, nukleotidi in vodotopni vitamini
16. Water soluble vitamins	1. Characteristics and structure of active parts of water soluble vitamnis. 2. Coenzyme forms of vitamins. 3. Biochemical insights into hypovitaminoses.	▪ Lecture U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Oksidoredukcijske reakcije (vitamin C) ▪ DOŠ: Lipidi, nukleotidi in vodotopni vitamini
17. Nucleotides	1. Purine and pyrimidine bases, structure and properties. 2. Nucleosides and nucleotides, structure and nomenclature. 3. Nucleotides and their role in storage and transmissison of energy. 4. Cyclic nucleotides as secondaty messengers. 5. Nucleotides as building blocks of nucleic acids. 6. Characteristic reactions and biochemical meaning.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Nukleinske kisline ▪ DOŠ: Lipidi, nukleotidi in vodotopni vitamini
18. Nucleic acids	1. Structure and properties of nucleic acids 2. Types of nucleic acids, biochemical composition and the role. 3. Physico-chemical basis of secondary structure 3. Layers of DNA structure. 4. Structure of different RNA molecules.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Nukleinske kisline ▪ DOŠ: Nukleinske kisline
19. Genome	1. The structure of human genome. Biochemical meaning of different	▪ Lecture

	nucleotide sequences. 2. The influence of changes in primary structure DNA on the protein structure. 3. The »Human Genom Project« and project »1000 genomes« and genomics. 4. Understanding the causes and consequences of genetic diseases / defects at the molecular level.	▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Nukleinske kisline
20. Proteins	1. Classification based on structure and function. 2. Primary and secondary structure of proteins; α-helix, β-structure, β-turn. 3. Tertiary and quarternary structure of proteins. Allosteric effects. 4. Protein folding and denaturation. 5. Biochemical aspects of protein conformational disorders.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Proteini ▪ DOS: Proteini.
21. Globular proteins, myoglobin and haemoglobin	1. Myoglobin, haemoglobin; structure and function. 2. Quarternary structure of haemoglobin, positive cooperativity, conformations T and R. 3. Alosteric modulators of haemoglobin; homotropic and heterotropic modulators O2, CO2, H+, 2,3-BPG. 4. CO and competitive inhibition of haemoglobin. 5. Types of haemoglobins: A, A2, F. 6. Biochemical basis of haemoglobinopathies	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja DOS: Proteini.
22. DNA-binding proteins	1. Histones; biochemical characteristics; structure of nucleosome. 2. Transcription factors; structural characteristics; DNA binding domains (Zn fingers), dimerization domains (Leu zipper).	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Proteini
23. Fibrillary proteins	1. Structure of keratins; structure-function relationship. 2. Structure of collagen; structure-function relationship. 3. Age and disease related changes in collagen; the importance of vitamin C.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja DOS: Proteini
24. Biochemical aspects of molecular motors	1. Transformation of chemical energy into mechanical energy. 2. Structure of muscle contractile proteins. 3. Biochemical concepts of smooth muscle contraction. 4. Biochemical aspects of molecular motor F_oF_1 ATPaze / ATP synthase.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Proteini
25. Membrane proteins and transport	1. Membrane proteins; structure-function relationship. 2. Kinetics and mechanism of transport: transporters and channels. 3. Biochemical aspects of ion transport, transport of glucose and drugs. 4. Structure and biochemical role of Na^+/K^+-ATPaze and Ca^{2+} pump.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja
26. Proteins and molecules involved in signal transmission	1. Biochemical mechanisms of signal transmission. 2. Structural characteristics of receptors. 3. Types of signaling molecules and secondary messangers. 4. The biochemical basis of the light-induced cycle and the connection	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja

	with vitamin A.	
27. Plasma proteins	1. Types and functions of plasma proteins. 2. Proteins as structural elements of lipoproteins 3. Biochemical basis of atherosclerosis.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja
28. Immunoglobulins	1. Structure of immunoglobulins. 2. Immunoglobulins and analytical methods: Western blot, ELISA. 3. Biochemical basis of diseases caused by inappropriate folding of immunoglobulins.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Proteini.
29. Enzymes	1. Enzymes - general structural and biochemical properties, specificity, basics of action. Enzyme activity, specific activity. 2. Isoenzymes. 3. Enzymatic reactions with cofactors, coenzymes and prostetic groups; connection with water-soluble vitamins. 4. Classification of enzymes and examples of reactions of representative representatives of individual enzymes.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Encimi ▪ DOS: Encimi
30. Mechanisms of enzyme catalysis	1. Transition state theory. 2. Induced fit. 3. General and specific acid-base catalysis. 4. Other mechanisms; covalent catalysis, catalysis with metal ions, entropy effect, steric stabilization.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja
31. Enzyme kinetics	1. Initial rates and Michaelis-Menten kinetics and equation. 2. Graphic displays of enzyme activity: Michaelis–Menten graph, Lineveawer–Burk graph. 3. Multistep reactions; K_m and k_{cat}. 4. Bisubstrate reactions; triple complex, double displacement - ping-pong mechanism.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Encimi
32. Enzyme inhibition	1. Reversible and irreversible enzyme inhibition. 2. Competitive enzyme inhibition. 3. Noncompetitive and incompetitive enzyme inhibition. 4. Suicide inhibitors.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja
33. Regulation of biochemical reactions	1. Metabolic pathways and feedback inhibition. 2. Alosteric enzymes; homo- in heterotropic modulators, sigmoid kinetics. 3. Other types of regulation; covalent modification, proteolytic cleavage. 4. Example: nucleotide synthesis by aspartate transcarbamoylase.	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja
34. Proteins and medicine	1. Proteins in medical diagnostics. 2. Proteins as targets for drug development. 3. Proteins as drugs.	▪ Lecture
35. Methods for characterization of biomolecules	1. Biochemical methods for separation and characterization of: carbohydrates, lipids,	▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox

	nucleic acids and proteins. 2. Targeted and omics approaches for studying biomolecules.	MM. Principles of Biochemistry, zadnja izdaja ▪ V: Biokemijske in molekularnobiološke laboratorijske tehnike

9. Other information

The exam procedure and application process is defined in the *regulation*. A student, who applied for the exam but later does not take the exam or withdraws form the exam, shall be considered as having failed the exam. There is no need to apply for partial written exams.

Laboratory safety rules
For safety reasons, the students must follow the laboratory safety rules. Clothes and bags must be stored in the lockers. No food or drinks are allowed in the laboratories. Students must wear laboratory coats while performing experiments. In certain exercises, students should wear the gloves they receive in the classroom. When handling certain chemicals, the students must protect their hands with gloves, which will be provided.

E-mails shall be answered during business hours.