



Course Regime

Course: CONCEPTS OF BIOCHEMISTRY

Study Programme: Medicine

Year of the Course: 1

Semester: Summer

Course type: Compulsory

Number of ECTS credits: 12

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

Parts (Modules) of the Course: /

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A. Hybrid teaching approach (HyFlex model)

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 uniform Master's Study Programmes of 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 delivered both in person and online at the same by the same lecturer. Part of the students are present in the lecture hall and another part of the students attend the lectures at a distance via videoconference. To ensure the epidemiological traceability of personal contacts in the event of SARS-Cov-2 infection in the group of students present in the lecture hall, a record of the presence will be kept. The records will be stored at the UL MF Secretariat and destroyed after one month. Records will not be used to monitor student attendance at lectures within the course. 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 online, 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 are held online. Students receive presentations with brief explanation of the topic and instructions for conducting seminars in the Online classroom. Discussion of complex parts of seminar will take place during the laboratory courses.

Laboratory courses are held in small groups at the Seminar rooms/Laboratories at the Institute for Biochemistry, Vrazov trg 2. 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 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 in an academic year. The student must defend the missed laboratory course at the next laboratory course, or latest at the last scheduled laboratory course. In the case the student has more than two justifiable absences, a formal request for permission to substitute 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. Chemical calculus assessment

After the first 6 laboratory courses students take a chemical calculus assessment, consisting of 6 assignments and lasts 30 minutes. Each assignment is scored with a maximum of 1 point. The final grade is descriptive: passed / failed. For the student to pass, he or she must collect at least 3 points. Students who have not passed the assessment must retake the test at the last scheduled laboratory course.

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 laboratory courses and passed the chemical calculus assessment. Specifically, the student has completed all laboratory course requirements when he or she has performed all laboratory courses according to the program and has signed experimental reports for all laboratory exercises.

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 laboratory courses and has passed chemical calculus assessment 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. Oral examinations will be held at the Institute of Biochemistry or other parts of Faculty of Medicine, subject to restrictive measures to prevent SARS-Cov-2 infection.

The student who applies for the exam but then does not attend the exam for any reason is considered to have failed the exam. If a student passes the written examination and for any reason does not wish to or cannot take the oral examination, he must notify the Student Office of the Institute of Biochemistry at least one working day before the date of the oral defence. If a student has not been able to take the oral exam due to force majeure, he / she shall notify the Student Office within three working days after the date of his / her oral exam. In both cases, the exam is assessed negatively. If a student passes a written examination and does not attend the oral examination and does not give an appropriate apology, the examination is assessed negatively.

Review of the written exams:

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 at the student's office 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, which will be carried out in the premises of UL MF, 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. In the case of remotely conducted exams, follow the instructions of the lecturers and technical staff supervising the exam. General instructions for performing student supervision while remotely writing exams are given in Article 9. 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 advise 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 A.L., Nelson D.L., Cox M.M. Principles of Biochemistry New York: Worth, last edition. (P)
- Marks D.B. et al., 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.	<ul style="list-style-type: none"> ▪ 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.	<ul style="list-style-type: none"> ▪ 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 hydrophilic and hydrophobic environment). 5. Water as reagent.	<ul style="list-style-type: none"> ▪ 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, K_w , pH; biochemical / biological relevance of pH. 8. Acids and bases; strength (dissociation rate, dissociation constant). 9. Neutralization of acids with bases et vice versa (titration curves, pH indicators). 10. Weak and strong electrolytes.	<ul style="list-style-type: none"> ▪ 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

	<p>11. Buffers; the definition of the buffer system, buffer capacity, the functioning of the buffer system.</p> <p>12. Relevance of pH maintenance in cells / organism. Buffer systems in the organism (extracellular, intracellular).</p> <p>13. Ionic strength of solutions; the influence of electrolyte concentration on ionic strength.</p> <p>14. Salt solubility and solubility product; examples of salt formation/ crystals in the organism hydroxy- and fluoroapatite in bones and teeth).</p>	
5. Thermodynamics	<p>1. Work and heat as a form of energy.</p> <p>2. First law of thermodynamics and enthalpy.</p> <p>3. Energy changes in biochemical reactions.</p> <p>4. Burnout and energy value of certain metabolic nutrients (carbohydrates, proteins).</p> <p>5. Hess law. Enthalpy of chemical bonding.</p> <p>6. Reversible / irreversible chemical reactions, entropy, second law of thermodynamics.</p> <p>7. Equilibrium of chemical reactions, standard state, spontaneous and non-spontaneous processes free energy, chemical potential.</p> <p>8. Effects of various factors on the chemical equilibrium.</p> <p>9. Coupled reactions, the importance for maintenance of life.</p> <p>10. ATP (structure, hydrolysis, activation of biomolecules).</p> <p>11. Other compounds with high phosphorylation potential (phosphoenol pyruvate, phosphocreatin).</p>	<ul style="list-style-type: none"> ▪ 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	<p>1. Oxidoreduction reactions; oxidoreduction couples, oxidation / reduction, oxidant / reducer.</p> <p>2. Flow of electrons and change in free energy.</p> <p>3. Standard state. Nernst equation.</p> <p>4. Oxidoreduction reactions in organism, respiratory chain.</p>	<ul style="list-style-type: none"> ▪ 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	<p>1. The course of the chemical reaction against the equilibrium.</p> <p>2. Energy profile of chemical and biochemical reactions.</p> <p>3. Reaction rate and rate constant; determination of the rate constant.</p> <p>4. Reaction order; determining the order of the reaction.</p> <p>5. The influence of various factors on the reaction rate.</p> <p>6. Catalysis, reaction mechanism, kinetics of catalyzed and non-catalyzed reactions.</p>	<ul style="list-style-type: none"> ▪ 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	<p>1. Membrane permeability depending on the biochemical properties of the substance.</p> <p>2. Thermodynamics of transport and transmembrane potential.</p> <p>3. Direct and indirect transport.</p> <p>4. Active transport: ATP hydrolysis and ionic gradient as the source of energy.</p>	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja

9. Carbon as the fundamental atom of biomolecules	<ol style="list-style-type: none"> 1. Carbon atom; electronic configuration, resonance, steric properties. 2. Bonds between carbon atoms and between carbon and other atoms. 	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Uvod v biokemijo
10. Biomolecules - general	<ol style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Uvod v biokemijo
11. Aminoacids	<ol style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Aminokisline ▪ DOS: Aminokisline in njihovi derivati
12. Peptides	<ol style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Aminokisline in peptidi
13. Biogenic amines	<ol style="list-style-type: none"> 1. The formation and types of biogenic amines. 2. Structure and function of adrenaline. 3. The formation and structure of thyroid hormones. 4. Mechanism of action on molecular level. 	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Aminokisline in njihovi derivati
14. Carbohydrates	<ol style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Ogljikovi hidrati ▪ DOS: Ogljikovi hidrati in njihovi derivati

	16. Structural characteristics of glycoproteins.	
15. Lipids	<ol style="list-style-type: none"> 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; unsaturated fatty acids, phosphoinositides. 7. Eikosanoids (prostaglandins, prostacyclins, tromboxanes and leukotrienes) 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. Molecular 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. 	<ul style="list-style-type: none"> ▪ 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	<ol style="list-style-type: none"> 1. Characteristics and structure of active parts of water soluble vitamnis. 2. Coenzyme forms of vitamins. 3. Biochemical insights into hypovitaminoses. 	<ul style="list-style-type: none"> ▪ 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	<ol style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> ▪ 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	<ol style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> ▪ 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	<ul style="list-style-type: none"> ▪ Lecture

	<p>nucleotide sequences.</p> <p>2. The influence of changes in primary structure DNA on the protein structure.</p> <p>3. The »Human Genom Project« and project »1000 genomes« and genomics.</p> <p>4. Understanding the causes and consequences of genetic diseases / defects at the molecular level.</p>	<ul style="list-style-type: none"> ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Nukleinske kisline
20. Proteins	<p>1. Classification based on structure and function.</p> <p>2. Primary and secondary structure of proteins; α-helix, β-structure, β-turn.</p> <p>3. Tertiary and quarternary structure of proteins. Allosteric effects.</p> <p>4. Protein folding and denaturation.</p> <p>5. Biochemical aspects of protein conformational disorders.</p>	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Proteini ▪ DOS: Proteini.
21. Globular proteins, myoglobin and haemoglobin	<p>1. Myoglobin, haemoglobin; structure and function.</p> <p>2. Quarternary structure of haemoglobin, positive cooperativity, conformations T and R.</p> <p>3. Alosteric modulators of haemoglobin; homotropic and heterotropic modulators O₂, CO₂, H⁺, 2,3-BPG.</p> <p>4. CO and competitive inhibition of haemoglobin.</p> <p>5. Types of haemoglobins: A, A₂, F.</p> <p>6. Biochemical basis of haemoglobinopathies</p>	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Proteini.
22. DNA-binding proteins	<p>1. Histones; biochemical characteristics; structure of nucleosome.</p> <p>2. Transcription factors; structural characteristics; DNA binding domains (Zn fingers), dimerization domains (Leu zipper).</p>	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Proteini
23. Fibrillary proteins	<p>1. Structure of keratins; structure-function relationship.</p> <p>2. Structure of collagen; structure-function relationship.</p> <p>3. Age and disease related changes in collagen; the importance of vitamin C.</p>	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Proteini
24. Biochemical aspects of molecular motors	<p>1. Transformation of chemical energy into mechanical energy.</p> <p>2. Structure of muscle contractile proteins.</p> <p>3. Biochemical concepts of smooth muscle contraction.</p> <p>4. Biochemical aspects of molecular motor F₀F₁ ATPaze / ATP synthase.</p>	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Proteini
25. Membrane proteins and transport	<p>1. Membrane proteins; structure-function relationship.</p> <p>2. Kinetics and mechanism of transport: transporters and channels.</p> <p>3. Biochemical aspects of ion transport, transport of glucose and drugs.</p> <p>4. Structure and biochemical role of Na⁺/K⁺-ATPaze and Ca²⁺ pump.</p>	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja
26. Proteins and molecules involved in signal transmission	<p>1. Biochemical mechanisms of signal transmission.</p> <p>2. Structural characteristics of receptors.</p> <p>3. Types of signaling molecules and secondary messengers.</p> <p>4. The biochemical basis of the light-induced cycle and the connection</p>	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja

	with vitamin A.	
27. Plasma proteins	<ol style="list-style-type: none"> Types and functions of plasma proteins. Proteins as structural elements of lipoproteins Biochemical basis of atherosclerosis. 	<ul style="list-style-type: none"> Lecture U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja
28. Immunoglobulins	<ol style="list-style-type: none"> Structure of immunoglobulins. Immunoglobulins and analytical methods: Western blot, ELISA. Biochemical basis of diseases caused by inappropriate folding of immunoglobulins. 	<ul style="list-style-type: none"> Lecture U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja DOS: Proteini.
29. Enzymes	<ol style="list-style-type: none"> Enzymes - general structural and biochemical properties, specificity, basics of action. Enzyme activity, specific activity. Isoenzymes. Enzymatic reactions with cofactors, coenzymes and prosthetic groups; connection with water-soluble vitamins. Classification of enzymes and examples of reactions of representative representatives of individual enzymes. 	<ul style="list-style-type: none"> Lecture U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja V: Encimi DOS: Encimi
30. Mechanisms of enzyme catalysis	<ol style="list-style-type: none"> Transition state theory. Induced fit. General and specific acid-base catalysis. Other mechanisms; covalent catalysis, catalysis with metal ions, entropy effect, steric stabilization. 	<ul style="list-style-type: none"> Lecture U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja
31. Enzyme kinetics	<ol style="list-style-type: none"> Initial rates and Michaelis-Menten kinetics and equation. Graphic displays of enzyme activity: Michaelis-Menten graph, Lineveawer-Burk graph. Multistep reactions; K_m and k_{cat} Bisubstrate reactions; triple complex, double displacement - ping-pong mechanism. 	<ul style="list-style-type: none"> Lecture U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja DOS: Encimi
32. Enzyme inhibition	<ol style="list-style-type: none"> Reversible and irreversible enzyme inhibition. Competitive enzyme inhibition. Noncompetitive and uncompetitive enzyme inhibition. Suicide inhibitors. 	<ul style="list-style-type: none"> Lecture U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja
33. Regulation of biochemical reactions	<ol style="list-style-type: none"> Metabolic pathways and feedback inhibition. Allosteric enzymes; homo- in heterotropic modulators, sigmoid kinetics. Other types of regulation; covalent modification, proteolytic cleavage. Example: nucleotide synthesis by aspartate transcarbamoylase. 	<ul style="list-style-type: none"> Lecture U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja
34. Proteins and medicine	<ol style="list-style-type: none"> Proteins in medical diagnostics. Proteins as targets for drug development. Proteins as drugs. 	<ul style="list-style-type: none"> Lecture
35. Methods for characterization of biomolecules	<ol style="list-style-type: none"> Biochemical methods for separation and characterization of: carbohydrates, lipids, 	<ul style="list-style-type: none"> 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

1. 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 from 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.

Guidelines and instructions for conducting distance learning and safety measures to prevent the spread of SARS-CoV-2 virus infection

General instructions for conducting student supervision during the distance assessment:

- Students must register for the videoconference session with their given **name and surname**.
- **Students must have a camera turned on while writing exams. The use of virtual wallpapers is prohibited.** We recommend that students choose an appropriate space, taking into account the suitability of the background that will be visible in the camera field. If the student does not turn on the camera while writing the exam, the exam will be annulled. The student can take the written exam in the next term under the conditions set out in the instructions.
- It is forbidden to use mobile phones and all other electronic devices and programs that enable capturing images while writing the exam. If a student has two computers, the other computer, not in use for writing the exam, must be turned off. While writing, communication with a mobile phone and programs that allow remote communication is prohibited.
- In the event that course holders supervise students **via videoconference** while writing a written exam, they must inform the students about the method of supervision **at least 5 days** before the exam.
- **Students are obliged to provide all the necessary equipment** (computer with camera, speakers and microphone, mobile phone) for the smooth implementation of video surveillance.
- The teacher can check the student identification document before the knowledge test, which the student displays in the camera field. He or she can also check that the student is alone in the room, that he or she does not have headphones and other accessories that are not allowed. During the oral exam, the teacher monitors and checks the student's behaviour during the exam.
- Authentication in oral and written exams in videoconferencing programs is allowed, but only if the videoconference session is not recorded and the recording is not saved. The identification of a student via videoconference is not disputable, as long as it is only an insight into an identity document before the start of the exam.
- Recording a student during oral or written exams and storing recordings is not permitted.
- **In case of suspicion of violations or violations** of the exam conduct (unannounced departure from the camera area, unexplained cancellation from the videoconferencing program and / or program for conducting written exams, suspicious observation of objects out of sight of the camera (eg books, notes...)) during the oral exam followed via videoconference, the exam supervisor reminds the student once and asks for an explanation. If the event is repeated again, the student's assignment is graded negatively. Violation of the rules is a disciplinary offense and is

dealt with in accordance with the provisions of the Rules on the examination and assessment of knowledge and skills and the Rules on disciplinary responsibility of students.

- Capturing additional data on a student's presence using tools that are not part of the program for conducting written examinations at a distance is allowed only if you provide a written justification as to why such a method is necessary. Send a written justification to the e-mail address ksz@mf.uni-lj.si. This information must be deleted immediately after the exam. The exception is the written record of the exam.
- Course providers must also inform students which of their digital data will be monitored during the distance test. Example of a letter in a notice:

Recommended letter on the review of personal data during the conduct of remote examinations (adjust the letter accordingly according to your method of implementation and your exam conduct):

Notice on the processing of personal data: your IP address, monitoring your behaviour on the computer during the exam (only information on whether and how many times you will leave the e-exam environment, your indication of the reason why you left the exam environment), will be kept at UL Faculty of Medicine, Institute of Biochemistry until the moment you pass the exam - if the exam environment detects that you wanted to leave it more times than allowed, and without giving a proper reason, the information will be kept until the violation is addressed at the level of the institute, or in the case of an established violation after consideration according to the Rules of disciplinary responsibility of students, until the expiration of the appeal period or until the faculty decides on your appeal. The collection of the said personal data is strictly necessary for the normal conduct of examinations during the Covid-19 epidemic, when the conduct of examinations in the lecture hall is not permitted. Despite the epidemic, the University of Ljubljana is obliged to carry out study programs (including examinations) in accordance with the ZViS, so the only feasible option is to conduct remote examinations - the method of implementation is thus necessary for performing a task in the public interest (point (e), first paragraph of article 6 GDPR).

// In the case of using the UL MF Online Classroom examination system, your personal data will be processed by the course holders and the online classroom team.//

You may at any time exercise access to your personal data, their correction or restriction of processing (under the terms of the GDPR) and the right to object to the processing. You can exercise your rights in writing at the address of the faculty. For help in exercising your rights, you can contact the authorized person for data protection (dpo@uni-lj.si). If you judge that we are not exercising your rights accordingly, you can complain to the Information Commissioner of the Republic of Slovenia.

B. Remote teaching

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 uniform Master's Study Programmes of 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 via videoconference:

Monday 8 – 10 AM

Friday 8 – 11 AM

DOŠ is organised in small groups via videoconference, 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 are held via videoconference. 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 PowerPoint presentation. 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 held online according to the teachers' instructions. Only students who are enrolled in the first year of studies can participate at the laboratory courses. At the end of the tutorial, students write a report in the course syllabus book and uploads it to the Online classroom. Each laboratory course is completed if 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 than two justifiable absences, a formal request for permission to substitute 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 student's group and the group in which he or she wishes to participate.

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

Chemical calculus assessment

After the first 6 laboratory courses students take a chemical calculus assessment, consisting of 6 assignments and lasts 30 minutes. Each assignment is scored with a maximum of 1 point. The final grade is descriptive: passed / failed. For the student to pass, he or she must collect at least 3 points. Students who have not passed the assessment must retake the test at the last scheduled laboratory course.

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 the chemical calculus assessment. 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 student 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. If a student passes the written examination and for any reason does not wish to or cannot take the oral examination, he must notify the Student Office of the Institute of Biochemistry at least one working day before the date of the oral defence. If a student has not been able to take the oral exam due to force majeure, he / she shall notify the Student Office within three working days after the date of his / her oral exam. In both cases, the exam is assessed negatively. If a student passes a written examination and does not attend the oral examination and does not give an appropriate apology, the examination is assessed negatively.

Review of the written exams:

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 at the student's office 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 remotely written exams or assessments, follow the instructions of the lecturers and technical staff supervising the exam. General instructions for performing student supervision while remotely writing exams are given in Article 9. 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.

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 advise 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 A.L., Nelson D.L., Cox M.M. Principles of Biochemistry New York: Worth, last edition. (P)
- Marks D.B. et al., 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.	<ul style="list-style-type: none"> ▪ 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.	<ul style="list-style-type: none"> ▪ 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 hydrophilic and hydrophobic environment). 5. Water as reagent.	<ul style="list-style-type: none"> ▪ 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, K_w , pH; biochemical / biological relevance of pH. 8. Acids and bases; strength (dissociation rate, dissociation constant). 9. Neutralization of acids with bases et vice versa (titration curves, pH indicators). 10. Weak and strong electrolytes.	<ul style="list-style-type: none"> ▪ 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

	<p>11. Buffers; the definition of the buffer system, buffer capacity, the functioning of the buffer system.</p> <p>12. Relevance of pH maintenance in cells / organism. Buffer systems in the organism (extracellular, intracellular).</p> <p>13. Ionic strength of solutions; the influence of electrolyte concentration on ionic strength.</p> <p>14. Salt solubility and solubility product; examples of salt formation/ crystals in the organism hydroxy- and fluoroapatite in bones and teeth).</p>	
5. Thermodynamics	<p>1. Work and heat as a form of energy.</p> <p>2. First law of thermodynamics and enthalpy.</p> <p>3. Energy changes in biochemical reactions.</p> <p>4. Burnout and energy value of certain metabolic nutrients (carbohydrates, proteins).</p> <p>5. Hess law. Enthalpy of chemical bonding.</p> <p>6. Reversible / irreversible chemical reactions, entropy, second law of thermodynamics.</p> <p>7. Equilibrium of chemical reactions, standard state, spontaneous and non-spontaneous processes free energy, chemical potential.</p> <p>8. Effects of various factors on the chemical equilibrium.</p> <p>9. Coupled reactions, the importance for maintenance of life.</p> <p>10. ATP (structure, hydrolysis, activation of biomolecules).</p> <p>11. Other compounds with high phosphorylation potential (phosphoenol pyruvate, phosphocreatin).</p>	<ul style="list-style-type: none"> ▪ 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	<p>1. Oxidoreduction reactions; oxidoreduction couples, oxidation / reduction, oxidant / reducer.</p> <p>2. Flow of electrons and change in free energy.</p> <p>3. Standard state. Nernst equation.</p> <p>4. Oxidoreduction reactions in organism, respiratory chain.</p>	<ul style="list-style-type: none"> ▪ 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	<p>1. The course of the chemical reaction against the equilibrium.</p> <p>2. Energy profile of chemical and biochemical reactions.</p> <p>3. Reaction rate and rate constant; determination of the rate constant.</p> <p>4. Reaction order; determining the order of the reaction.</p> <p>5. The influence of various factors on the reaction rate.</p> <p>6. Catalysis, reaction mechanism, kinetics of catalyzed and non-catalyzed reactions.</p>	<ul style="list-style-type: none"> ▪ 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	<p>1. Membrane permeability depending on the biochemical properties of the substance.</p> <p>2. Thermodynamics of transport and transmembrane potential.</p> <p>3. Direct and indirect transport.</p> <p>4. Active transport: ATP hydrolysis and ionic gradient as the source of energy.</p>	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja

9. Carbon as the fundamental atom of biomolecules	<ol style="list-style-type: none"> 1. Carbon atom; electronic configuration, resonance, steric properties. 2. Bonds between carbon atoms and between carbon and other atoms. 	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Uvod v biokemijo
10. Biomolecules - general	<ol style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Uvod v biokemijo
11. Aminoacids	<ol style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Aminokisline ▪ DOS: Aminokisline in njihovi derivati
12. Peptides	<ol style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Aminokisline in peptidi
13. Biogenic amines	<ol style="list-style-type: none"> 1. The formation and types of biogenic amines. 2. Structure and function of adrenaline. 3. The formation and structure of thyroid hormones. 4. Mechanism of action in molecular level. 	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Aminokisline in njihovi derivati
14. Carbohydrates	<ol style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Ogljikovi hidrati ▪ DOS: Ogljikovi hidrati in njihovi derivati

15. Lipids	<p>16. Structural characteristics of glycoproteins.</p> <ol style="list-style-type: none"> 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; unsaturated fatty acids, phosphoinositides. 7. Eikosanoids (prostaglandins, prostacyclins, tromboxanes and leukotrienes) structure and function. 8. Lipid transport in aqueous media, emulgation, micelles, lyposomes, lipoptoreins. 9. Steroids; structure, classification, 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. Molecular 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. 	<ul style="list-style-type: none"> ▪ 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	<ol style="list-style-type: none"> 1. Characteristics and structure of active parts of water soluble vitamins. 2. Coenzyme forms of vitamins. 3. Biochemical insights into hypovitaminoses. 	<ul style="list-style-type: none"> ▪ 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	<ol style="list-style-type: none"> 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 secondary messengers. 5. Nucleotides as building blocks of nucleic acids. 6. Characteristic reactions and biochemical meaning. 	<ul style="list-style-type: none"> ▪ 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	<ol style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> ▪ 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	<ul style="list-style-type: none"> ▪ Lecture

	<p>nucleotide sequences.</p> <p>2. The influence of changes in primary structure DNA on the protein structure.</p> <p>3. The »Human Genom Project« and project »1000 genomes« and genomics.</p> <p>4. Understanding the causes and consequences of genetic diseases / defects at the molecular level.</p>	<ul style="list-style-type: none"> ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Nukleinske kisline
20. Proteins	<p>1. Classification based on structure and function.</p> <p>2. Primary and secondary structure of proteins; α-helix, β-structure, β-turn.</p> <p>3. Tertiary and quarternary structure of proteins. Allosteric effects.</p> <p>4. Protein folding and denaturation.</p> <p>5. Biochemical aspects of protein conformational disorders.</p>	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Proteini ▪ DOS: Proteini.
21. Globular proteins, myoglobin and haemoglobin	<p>1. Myoglobin, haemoglobin; structure and function.</p> <p>2. Quarternary structure of haemoglobin, positive cooperativity, conformations T and R.</p> <p>3. Alosteric modulators of haemoglobin; homotropic and heterotropic modulators O₂, CO₂, H⁺, 2,3-BPG.</p> <p>4. CO and competitive inhibition of haemoglobin.</p> <p>5. Types of haemoglobins: A, A₂, F.</p> <p>6. Biochemical basis of haemoglobinopathies</p>	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Proteini.
22. DNA-binding proteins	<p>1. Histones; biochemical characteristics; structure of nucleosome.</p> <p>2. Transcription factors; structural characteristics; DNA binding domains (Zn fingers), dimerization domains (Leu zipper).</p>	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Proteini
23. Fibrillary proteins	<p>1. Structure of keratins; structure-function relationship.</p> <p>2. Structure of collagen; structure-function relationship.</p> <p>3. Age and disease related changes in collagen; the importance of vitamin C.</p>	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Proteini
24. Biochemical aspects of molecular motors	<p>1. Transformation of chemical energy into mechanical energy.</p> <p>2. Structure of muscle contractile proteins.</p> <p>3. Biochemical concepts of smooth muscle contraction.</p> <p>4. Biochemical aspects of molecular motor F₀F₁ ATPaze / ATP synthase.</p>	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Proteini
25. Membrane proteins and transport	<p>1. Membrane proteins; structure-function relationship.</p> <p>2. Kinetics and mechanism of transport: transporters and channels.</p> <p>3. Biochemical aspects of ion transport, transport of glucose and drugs.</p> <p>4. Structure and biochemical role of Na⁺/K⁺-ATPaze and Ca²⁺ pump.</p>	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja
26. Proteins and molecules involved in signal transmission	<p>1. Biochemical mechanisms of signal transmission.</p> <p>2. Structural characteristics of receptors.</p> <p>3. Types of signaling molecules and secondary messengers.</p> <p>4. The biochemical basis of the light-induced cycle and the connection</p>	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja

	with vitamin A.	
27. Plasma proteins	<ol style="list-style-type: none"> Types and functions of plasma proteins. Proteins as structural elements of lipoproteins Biochemical basis of atherosclerosis. 	<ul style="list-style-type: none"> Lecture U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja
28. Immunoglobulins	<ol style="list-style-type: none"> Structure of immunoglobulins. Immunoglobulins and analytical methods: Western blot, ELISA. Biochemical basis of diseases caused by inappropriate folding of immunoglobulins. 	<ul style="list-style-type: none"> Lecture U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja DOS: Proteini.
29. Enzymes	<ol style="list-style-type: none"> Enzymes - general structural and biochemical properties, specificity, basics of action. Enzyme activity, specific activity. Isoenzymes. Enzymatic reactions with cofactors, coenzymes and prosthetic groups; connection with water-soluble vitamins. Classification of enzymes and examples of reactions of representative representatives of individual enzymes. 	<ul style="list-style-type: none"> Lecture U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja V: Encimi DOS: Encimi
30. Mechanisms of enzyme catalysis	<ol style="list-style-type: none"> Transition state theory. Induced fit. General and specific acid-base catalysis. Other mechanisms; covalent catalysis, catalysis with metal ions, entropy effect, steric stabilization. 	<ul style="list-style-type: none"> Lecture U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja
31. Enzyme kinetics	<ol style="list-style-type: none"> Initial rates and Michaelis-Menten kinetics and equation. Graphic displays of enzyme activity: Michaelis-Menten graph, Lineveawer-Burk graph. Multistep reactions; K_m and k_{cat} Bisubstrate reactions; triple complex, double displacement - ping-pong mechanism. 	<ul style="list-style-type: none"> Lecture U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja DOS: Encimi
32. Enzyme inhibition	<ol style="list-style-type: none"> Reversible and irreversible enzyme inhibition. Competitive enzyme inhibition. Noncompetitive and uncompetitive enzyme inhibition. Suicide inhibitors. 	<ul style="list-style-type: none"> Lecture U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja
33. Regulation of biochemical reactions	<ol style="list-style-type: none"> Metabolic pathways and feedback inhibition. Allosteric enzymes; homo- in heterotropic modulators, sigmoid kinetics. Other types of regulation; covalent modification, proteolytic cleavage. Example: nucleotide synthesis by aspartate transcarbamoylase. 	<ul style="list-style-type: none"> Lecture U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja
34. Proteins and medicine	<ol style="list-style-type: none"> Proteins in medical diagnostics. Proteins as targets for drug development. Proteins as drugs. 	<ul style="list-style-type: none"> Lecture
35. Methods for characterization of biomolecules	<ol style="list-style-type: none"> Biochemical methods for separation and characterization of: carbohydrates, lipids, 	<ul style="list-style-type: none"> 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 from 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.

Guidelines and instructions for conducting distance learning and safety measures to prevent the spread of SARS-CoV-2 virus infection

General instructions for conducting student supervision during the distance assessment:

- Students must register for the videoconference session with their given **name and surname**.
- **Students must have a camera turned on while writing exams. The use of virtual wallpapers is prohibited.** We recommend that students choose an appropriate space, taking into account the suitability of the background that will be visible in the camera field. If the student does not turn on the camera while writing the exam, the exam will be annulled. The student can take the written exam in the next term under the conditions set out in the instructions.
- It is forbidden to use mobile phones and all other electronic devices and programs that enable capturing images while writing the exam. If a student has two computers, the other computer, not in use for writing the exam, must be turned off. While writing, communication with a mobile phone and programs that allow remote communication is prohibited.
- In the event that course holders supervise students **via videoconference** while writing a written exam, they must inform the students about the method of supervision **at least 5 days** before the exam.
- **Students are obliged to provide all the necessary equipment** (computer with camera, speakers and microphone, mobile phone) for the smooth implementation of video surveillance.
- The teacher can check the student identification document before the knowledge test, which the student displays in the camera field. He or she can also check that the student is alone in the room, that he or she does not have headphones and other accessories that are not allowed. During the oral exam, the teacher monitors and checks the student's behaviour during the exam.
- Authentication in oral and written exams in videoconferencing programs is allowed, but only if the videoconference session is not recorded and the recording is not saved. The identification of a student via videoconference is not disputable, as long as it is only an insight into an identity document before the start of the exam.
- Recording a student during oral or written exams and storing recordings is not permitted.
- **In case of suspicion of violations or violations** of the exam conduct (unannounced departure from the camera area, unexplained cancellation from the videoconferencing program and / or program for conducting written exams, suspicious observation of objects out of sight of the camera (eg books, notes...)) during the oral exam followed via videoconference, the exam supervisor reminds the student once and asks for an explanation. If the event is repeated again, the student's assignment is graded negatively. Violation of the rules is a disciplinary offense and is

dealt with in accordance with the provisions of the Rules on the examination and assessment of knowledge and skills and the Rules on disciplinary responsibility of students.

- Capturing additional data on a student's presence using tools that are not part of the program for conducting written examinations at a distance is allowed only if you provide a written justification as to why such a method is necessary. Send a written justification to the e-mail address ksz@mf.uni-lj.si. This information must be deleted immediately after the exam. The exception is the written record of the exam.
- Course providers must also inform students which of their digital data will be monitored during the distance test. Example of a letter in a notice:

Recommended letter on the review of personal data during the conduct of remote examinations (adjust the letter accordingly according to your method of implementation and your exam conduct):

Notice on the processing of personal data: your IP address, monitoring your behaviour on the computer during the exam (only information on whether and how many times you will leave the e-exam environment, your indication of the reason why you left the exam environment), will be kept at UL Faculty of Medicine, Institute of Biochemistry until the moment you pass the exam - if the exam environment detects that you wanted to leave it more times than allowed, and without giving a proper reason, the information will be kept until the violation is addressed at the level of the institute, or in the case of an established violation after consideration according to the Rules of disciplinary responsibility of students, until the expiration of the appeal period or until the faculty decides on your appeal. The collection of the said personal data is strictly necessary for the normal conduct of examinations during the Covid-19 epidemic, when the conduct of examinations in the lecture hall is not permitted. Despite the epidemic, the University of Ljubljana is obliged to carry out study programs (including examinations) in accordance with the ZViS, so the only feasible option is to conduct remote examinations - the method of implementation is thus necessary for performing a task in the public interest (point (e), first paragraph of article 6 GDPR).

// In the case of using the UL MF Online Classroom examination system, your personal data will be processed by the course holders and the online classroom team.//

You may at any time exercise access to your personal data, their correction or restriction of processing (under the terms of the GDPR) and the right to object to the processing. You can exercise your rights in writing at the address of the faculty. For help in exercising your rights, you can contact the authorized person for data protection (dpo@uni-lj.si). If you judge that we are not exercising your rights accordingly, you can complain to the Information Commissioner of the Republic of Slovenia.

C. Study regime in the absence of restrictive measures to prevent SARS-Cov-2 infection

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 uniform Master's Study Programmes of 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 than two justifiable absences, a formal request for permission to substitute 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 student's group and the group in which he or she wishes to participate.

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

Chemical calculus assessment

After the first 6 laboratory courses students take a chemical calculus assessment, consisting of 6 assignments and lasts 30 minutes. Each assignment is scored with a maximum of 1 point. The final grade is descriptive: passed / failed. For the student to pass, he or she must collect at least 3 points. Students who have not passed the assessment must retake the test at the last scheduled laboratory course.

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 the chemical calculus assessment. 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 student 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. If a student passes the written examination and for any reason does not wish to or cannot take the oral examination, he must notify the Student Office of the Institute of Biochemistry at least one working day before the date of the oral defense. If a student has not been able to take the oral exam due to force majeure, he / she shall notify the Student Office within three working days after the date of his / her oral exam. In both cases, the exam is assessed negatively. If a student passes a written examination and does not attend the oral examination and does not give an appropriate apology, the examination is assessed negatively.

Review of the written exams:

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 at the student's office 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 A.L., Nelson D.L., Cox M.M. Principles of Biochemistry New York: Worth, last edition. (P)
- Marks D.B. et al., 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.	<ul style="list-style-type: none"> ▪ 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.	<ul style="list-style-type: none"> ▪ 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 hydrophilic and hydrophobic environment). 5. Water as reagent.	<ul style="list-style-type: none"> ▪ 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, K_w , pH; biochemical / biological relevance of pH. 8. Acids and bases; strength (dissociation rate, dissociation constant). 9. Neutralization of acids with bases et vice versa (titration curves, pH indicators). 10. Weak and strong electrolytes.	<ul style="list-style-type: none"> ▪ 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

	<p>11. Buffers; the definition of the buffer system, buffer capacity, the functioning of the buffer system.</p> <p>12. Relevance of pH maintenance in cells / organism. Buffer systems in the organism (extracellular, intracellular).</p> <p>13. Ionic strength of solutions; the influence of electrolyte concentration on ionic strength.</p> <p>14. Salt solubility and solubility product; examples of salt formation/crystals in the organism hydroxy- and fluoroapatite in bones and teeth).</p>	
5. Thermodynamics	<p>1. Work and heat as a form of energy.</p> <p>2. First law of thermodynamics and enthalpy.</p> <p>3. Energy changes in biochemical reactions.</p> <p>4. Burnout and energy value of certain metabolic nutrients (carbohydrates, proteins).</p> <p>5. Hess law. Enthalpy of chemical bonding.</p> <p>6. Reversible / irreversible chemical reactions, entropy, second law of thermodynamics.</p> <p>7. Equilibrium of chemical reactions, standard state, spontaneous and non-spontaneous processes free energy, chemical potential.</p> <p>8. Effects of various factors on the chemical equilibrium.</p> <p>9. Coupled reactions, the importance for maintenance of life.</p> <p>10. ATP (structure, hydrolysis, activation of biomolecules).</p> <p>11. Other compounds with high phosphorylation potential (phosphoenol pyruvate, phosphocreatin).</p>	<ul style="list-style-type: none"> ▪ 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	<p>1. Oxidoreduction reactions; oxidoreduction couples, oxidation / reduction, oxidant / reducer.</p> <p>2. Flow of electrons and change in free energy.</p> <p>3. Standard state. Nernst equation.</p> <p>4. Oxidoreduction reactions in organism, respiratory chain.</p>	<ul style="list-style-type: none"> ▪ 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	<p>1. The course of the chemical reaction against the equilibrium.</p> <p>2. Energy profile of chemical and biochemical reactions.</p> <p>3. Reaction rate and rate constant; determination of the rate constant.</p> <p>4. Reaction order; determining the order of the reaction.</p> <p>5. The influence of various factors on the reaction rate.</p> <p>6. Catalysis, reaction mechanism, kinetics of catalyzed and non-catalyzed reactions.</p>	<ul style="list-style-type: none"> ▪ 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	<p>1. Membrane permeability depending on the biochemical properties of the substance.</p> <p>2. Thermodynamics of transport and transmembrane potential.</p> <p>3. Direct and indirect transport.</p> <p>4. Active transport: ATP hydrolysis and ionic gradient as the source of energy.</p>	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja

9. Carbon as the fundamental atom of biomolecules	<ol style="list-style-type: none"> 1. Carbon atom; electronic configuration, resonance, steric properties. 2. Bonds between carbon atoms and between carbon and other atoms. 	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Uvod v biokemijo
10. Biomolecules - general	<ol style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Uvod v biokemijo
11. Aminoacids	<ol style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Aminokisljine ▪ DOS: Aminokisljine in njihovi derivati
12. Peptides	<ol style="list-style-type: none"> 1. Peptide bond; formation, strength 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 insulin. 5. Basics of peptide hormone activity at the molecular level. 	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Aminokisljine in peptidi
13. Biogenic amines	<ol style="list-style-type: none"> 1. The formation and types of biogenic amines. 2. Structure and function of adrenaline. 3. The formation and structure of thyroid hormones. 4. Mechanism of action on molecular level. 	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ DOS: Aminokisljine in njihovi derivati
14. Carbohydrates	<ol style="list-style-type: none"> 1. Definition and distribution. 2. Monosaccharides aldoses and ketoses, representatives, structure and meaning. 3. Monosaccharide derivatives; amino-, acetyl-, alkyl- and sulfoderivatives 4. Optical isomerism 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 (ABO system). 11. Polysaccharides: monoglycane, heteroglycans. 12. Starch, structure, biochemical meaning. 13. Structural polysaccharides; cellulose, chitin, glukosaminoglycans. 14. Hydrolysis of glycoside bonds by polysaccharides. 15. Bacterial cell wall; structure, biochemical stability. 	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja ▪ V: Ogljikovi hidrati ▪ DOS: Ogljikovi hidrati in njihovi derivati

	16. Structural characteristics of glycoproteins.	
15. Lipids	<ol style="list-style-type: none"> 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; unsaturated fatty acids, phosphoinositides. 7. Eikosanoids (prostaglandins, prostacyclins, tromboxanes and leukotrienes) 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. Molecular 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. 	<ul style="list-style-type: none"> ▪ 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	<ol style="list-style-type: none"> 1. Characteristics and structure of active parts of water soluble vitamnis. 2. Coenzyme forms of vitamins. 3. Biochemical insights into hypovitaminoses. 	<ul style="list-style-type: none"> ▪ 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	<ol style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> ▪ 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	<ol style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> ▪ 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	<ul style="list-style-type: none"> ▪ 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.	<ul style="list-style-type: none"> ▪ 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.	<ul style="list-style-type: none"> ▪ 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 O ₂ , CO ₂ , H ⁺ , 2,3-BPG. 4. CO and competitive inhibition of haemoglobin. 5. Types of haemoglobins: A, A ₂ , F. 6. Biochemical basis of haemoglobinopathies	<ul style="list-style-type: none"> ▪ 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).	<ul style="list-style-type: none"> ▪ 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.	<ul style="list-style-type: none"> ▪ 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 ₀ F ₁ ATPaze / ATP synthase.	<ul style="list-style-type: none"> ▪ 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.	<ul style="list-style-type: none"> ▪ 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 messengers. 4. The biochemical basis of the light-induced cycle and the connection	<ul style="list-style-type: none"> ▪ Lecture ▪ U: Lehninger AL, Nelson DL, Cox MM. Principles of Biochemistry, zadnja izdaja

	with vitamin A.	
27. Plasma proteins	7. Types and functions of plasma proteins. 8. Proteins as structural elements of lipoproteins 9. Biochemical basis of atherosclerosis.	<ul style="list-style-type: none"> ▪ 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.	<ul style="list-style-type: none"> ▪ 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 prosthetic groups; connection with water-soluble vitamins. 4. Classification of enzymes and examples of reactions of representative representatives of individual enzymes.	<ul style="list-style-type: none"> ▪ 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.	<ul style="list-style-type: none"> ▪ 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, Lineweaver-Burk graph. 3. Multistep reactions; K_m and k_{cat} 4. Bisubstrate reactions; triple complex, double displacement - ping-pong mechanism.	<ul style="list-style-type: none"> ▪ 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 uncompetitive enzyme inhibition. 4. Suicide inhibitors.	<ul style="list-style-type: none"> ▪ 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. Allosteric enzymes; homo- in heterotropic modulators, sigmoid kinetics. 3. Other types of regulation; covalent modification, proteolytic cleavage. 4. Example: nucleotide synthesis by aspartate transcarbamoylase.	<ul style="list-style-type: none"> ▪ 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.	<ul style="list-style-type: none"> ▪ Lecture
35. Methods for characterization of biomolecules	1. Biochemical methods for separation and characterization of: carbohydrates, lipids,	<ul style="list-style-type: none"> ▪ 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 from 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.